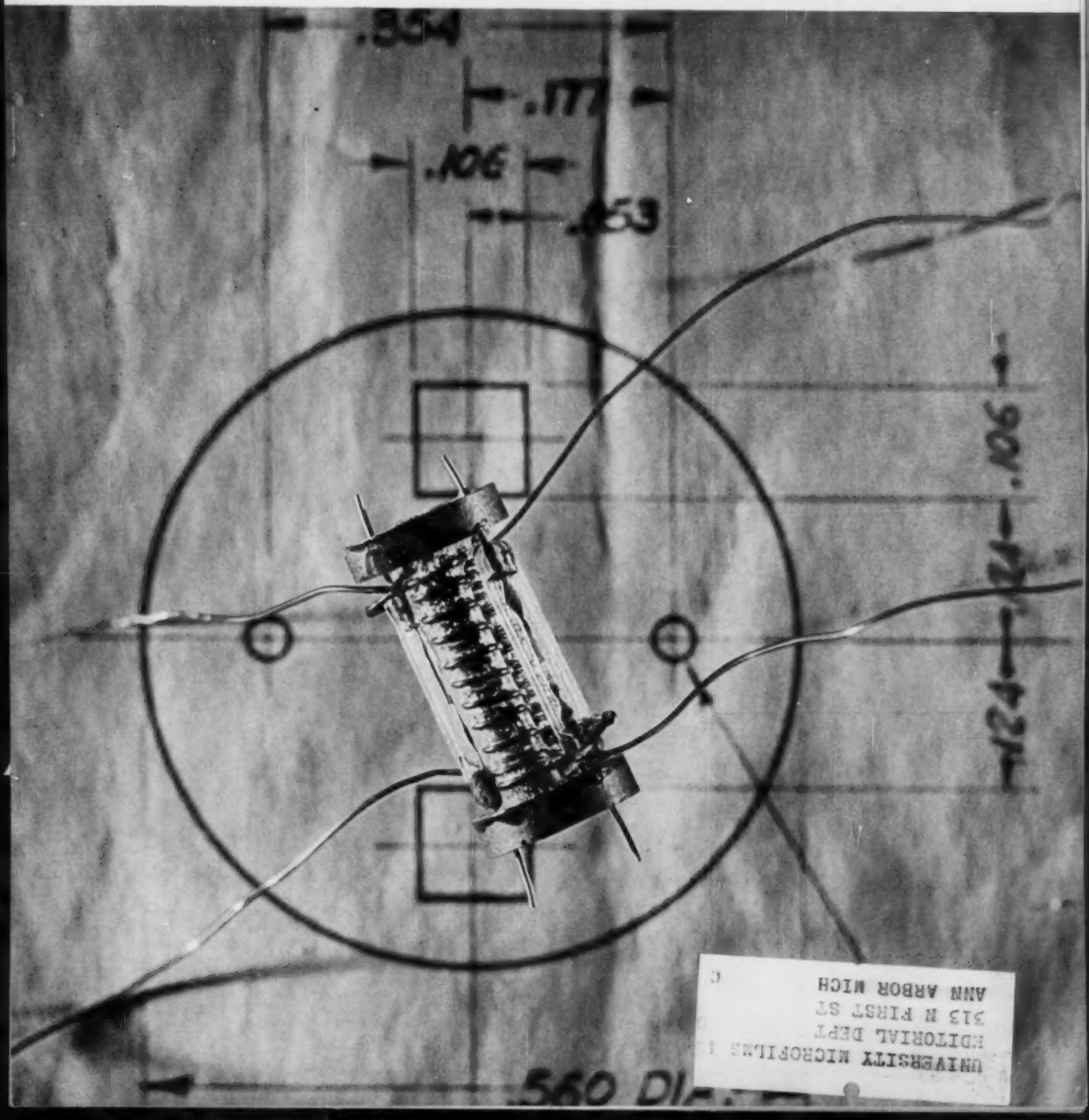
September 30, 1960

electronics

SPECIAL REPORT *Tiny magnetic switch (below) closes in microseconds, needs no power to keep it closed. It's one of the new electromechanical devices for electronics.* *See p 57*

A McGraw-Hill Publication 75 Cents



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ANN ARBOR MICH

Here's Your Chance to See The Strobotac and A Number of other NEW G-R Instruments at the Electronic Instrument Manufacturers Exhibit

Sagamore Room	Treadway Inn	Nelson House	The Meadowbrook	Cherry Hill Inn
Roosevelt Field Shopping Center	Norwalk, Conn.	Poughkeepsie, N. Y.	Cedar Grove, N. J.	Moorestown, N. J.
Long Island, New York	October 11	October 13	October 17	October 19-20
October 5-6				

Jointly Sponsored by FXR Inc. • General Radio Co. • Lambda Electronics Corp. • Panoramic Radio Products Co. • Tektronix, Inc. • Sensitive Research Instrument Corp.

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

September 30, 1960

electronics

A McGraw-Hill Publication 75 Cents

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ENGINEERING

Ferreed switch by Bell Labs uses ferrite as part of the magnetic circuit, combines mechanical action with electronics. See p 62 COVER

Electromechanical Devices and Systems for Electronics. A Special Report covering relays, contacts, switching, rotating devices, timers and actuators. By M. F. Tomaino and G. J. Flynn 57

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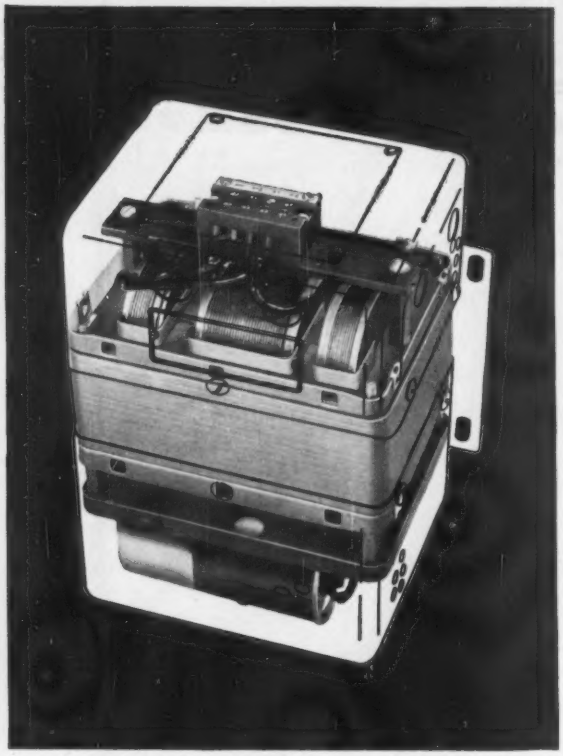
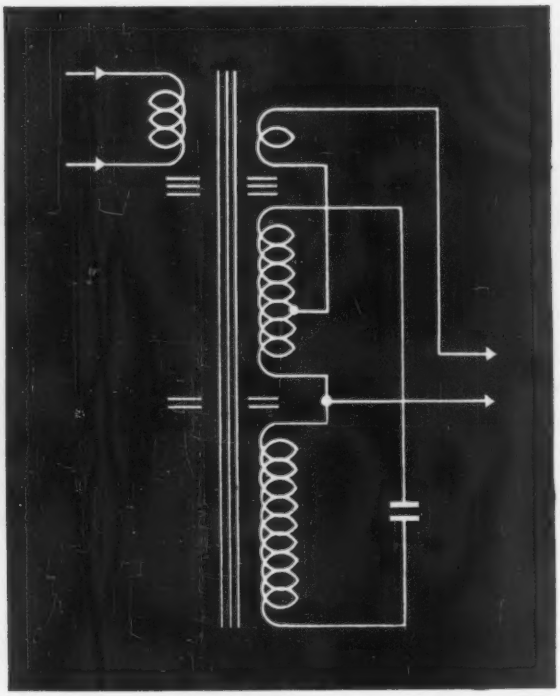
What's missing in this Sola voltage regulator?



Phantom view shows simplicity of Sola design. Note absence of components requiring maintenance such as motors, gears, contactors, tubes and relays.

Schematic diagram indicates the complete reliance on static elements. This is the circuit of a representative Type CVS regulator which delivers output having less than 3% total rms harmonic content.



When they designed the Sola Constant Voltage Transformer, what did they leave out? Trouble, for one thing. Original equipment manufacturers and plant engineers know that when you build in simplicity, you build out maintenance headaches.

The two illustrations at the left show clearly the Sola's few parts and straightforward design. This compact simplicity is possible because Sola regulators employ static-magnetic methods of voltage control.

The basic Sola design eliminates moving parts, renewable parts, manual adjustments, routine maintenance, and spare parts stock. Because there is nothing to wear out, no tubes to burn out — you know that when you specify Sola voltage stabilization, you automatically specify trouble-free reliability.

Despite this simplification, the Sola gives you these performance benefits: ±1% regulation over input voltage variations as great as ±15%, response time of 1.5 cycles or less, protection against short circuits for itself and its load, a high degree of isolation between input and output circuits, and negligible external field. Type CVS (illustrated with typical circuit diagram) delivers a commercial sine wave with less than 3% total rms harmonic content.

Sola static-magnetic units are available for regulation of common line voltages, as well as filament, plate-filament, computer-circuit and variable voltage outputs. They can also be supplied in step-up and step-down ratios to replace conventional non-regulating transformers.

Whether you are developing new electric or electronic equipment, or have a specific voltage regulation problem, your nearest Sola sales engineer will be happy to discuss your requirements with you.

Write for Bulletin 7J-CV

SOLA

SOLA ELECTRIC CO.
Busse Rd. at Lunt,

BP C

A Division of Basic Products Corporation
Elk Grove, Illinois

DESIGN WITH ARNOLD 6T CORES... SAME-DAY SHIPMENT OF STANDARD DELTAMAX CORE SIZES

Arnold 6T tape cores (aluminum-cased and hermetically-sealed) offer you three very important design advantages. *One:* Maximum compactness, comparable to or exceeding that previously offered only by plastic-cased cores. *Two:* Maximum built-in protection against environmental hazards. *Three:* Require no supplementary insulation prior to winding and can be vacuum impregnated after winding.

Now we've added a fourth vital advantage: Maximum availability. An initial stock of approximately 20,000 Deltamax 1, 2 and 4-mil tape cores in the proposed EIA standard sizes (See AIEE Publication No. 430) is ready on warehouse shelves for your convenience. From this revolving stock, you can get immediate shipment (*the same day order is received*) on cores in quantities from prototype lots to regular production requirements.

Use Arnold 6T cores in your designs for improved performance and reduced cost. They're guaranteed against 1000-volt breakdown . . . guaranteed to meet military test specifications for resistance to vibration and shock . . . guaranteed also to meet military specifications for operating temperatures. The 6T hermetic casing method is extra rigid to protect against strains.

Let us supply *your* requirements. Full data (Bulletin TC-101A and Supplements) on request. • Write *The Arnold Engineering Company, Main Office and Plant, Marengo, Ill.*

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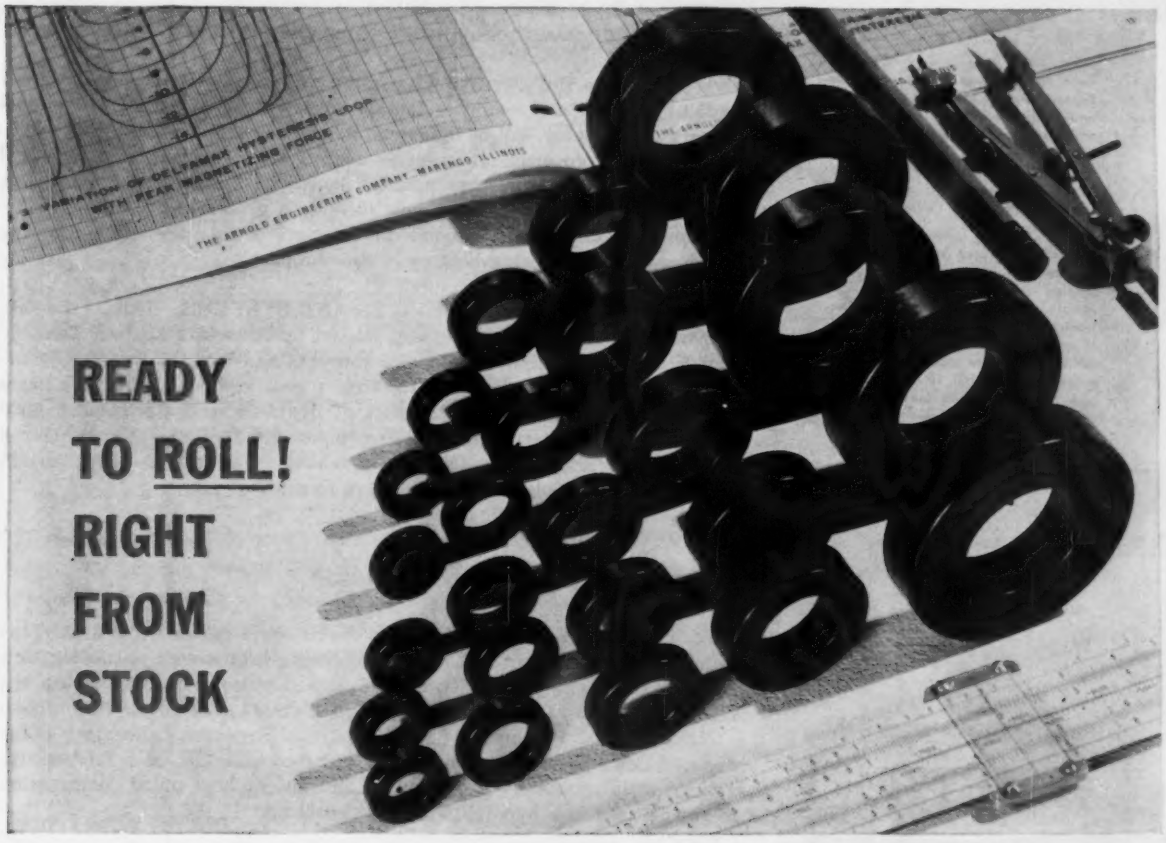

CROSSTALK

INFORMATION PROCESSING. The biggest market for electronic digital computers and peripheral equipment during the next decade may be in a field where today research activity is high but practical application low. The field is information processing.

Information processing is a step above data processing. A data-processing system handles numerical quantities and specific, orderly information such as a worker's sex, occupation or place of birth. An information processing system, on the other hand, would accept material in disorderly fashion, material whose meaning is possibly obscured by words of comparatively low information content. A treatise on economics might be an example.

Information processing would include automatic translation, indexing, abstracting and retrieval. High-speed input without manual key punching, output speed fast enough to keep up with computer operations and high-capacity memories all would be implicit in the system.

The elemental hardware for such an automatic library is indeed within our grasp today. Several electronic-optical character recognition systems have been successfully demonstrated. Electronic printing devices capable of 4,000-word-a-minute operation are available. High-capacity memories, usually photographic, also are available, while developments in thin films, cryogenics and microcircuits point the way to electronic memories of prodigious capacity. Computer programs for automatic abstracting based upon statistical analysis of word occurrence have been written. Computer speed presents some limitation to fully implementing such systems but this speed is being increased all the time.

Electronic information processing is truly essential if science and engineering are to advance as they should. Otherwise, some of our best brains will continue to be wasted in searching literature and reinventing the wheel.

What's more, information processing will mean big business to our industry. Immense computer installations will be required. First customers undoubtedly will be industrial firms with extensive research establishments and government agencies dealing with scientific and technical information. Probably other business firms will set up automatic libraries on a service basis much as we now have data processing centers. Information processing could become in the next decade the same booming business data processing became in the one past.

ELECTROMECHANICAL DEVICES AND SYSTEMS. That is the subject of this issue's 24-page Special Report by Associate Editors Tomaino and Flynn. You'll learn about new concepts and trends in switching devices, rotating devices, actuators, timers and readout devices. Charts specify the operating characteristics of hydraulic and electromechanical systems, and show you the Size 5 components that must be developed before complete Size 5 systems are a reality. For information you will want to save for future reference, turn to p 57.

Coming In Our October 7 Issue

PULSE COMPRESSION RADAR. Use of short pulses is, as a rule, the easiest and most direct method for achieving high range resolution in a radar system. By transmitting a stretched pulse and compressing the received pulse, a shorter pulse with high effective peak power is obtained.

Next week, G. P. Ohman of the U. S. Naval Research Laboratory radar division describes pulse compression radar techniques. His informative article explains the basic technique and shows how pulse compression might be used in a hypothetical radar system.

electronics

Sept. 30, 1960 Volume 33 Number 40

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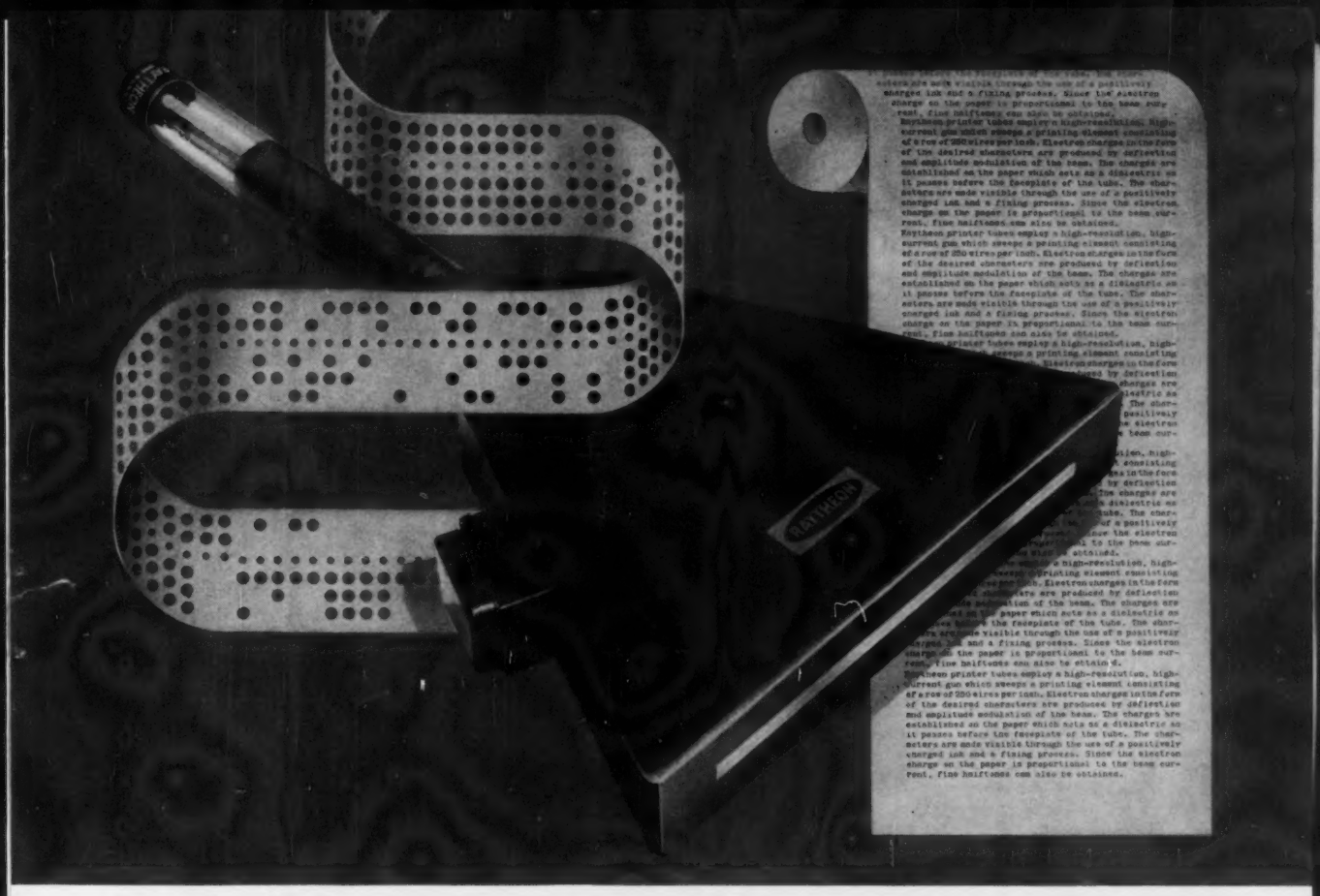


New Raytheon Cathode Ray Printer Tubes Print as Fast as Computers Think!

Raytheon cathode ray printer tubes now make possible the design of extremely high speed electronic printing equipment capable of printing 20,000 characters per second – or over 10,000 lines of computer information per minute – fast enough to keep pace with the output of modern computers.

These new tubes bring into focus a host of amazing new applications. Instant coast-to-coast transmission of mail – continuous photographic recording of freight traffic movement – incredibly fast printing of labels, or facsimile data – these are just a few examples.

Four developmental Raytheon printer tubes, the CK 1366 and CK 1368 with single row printing elements and the forty row CK 1367 and CK 1369, are available for producing writing widths of approximately 2¾ and 8⅝ inches. For complete technical data and design assistance, please write to: Raytheon, Industrial Components Division, 55 Chapel St., Newton 58, Mass.

HOW IT WORKS. Raytheon printer tubes employ a high-resolution, high-current gun which sweeps a printing element consisting of a row of 250 wires per inch. Electron charges in the form of the desired characters are produced by deflection and amplitude modulation of the beam. The charges are established on the paper which acts as a dielectric as it passes before the faceplate of the tube. The characters are made visible through the use of a positively charged ink and a fixing process. Since the electron charge on the paper is proportional to the beam current, fine halftones can also be obtained.

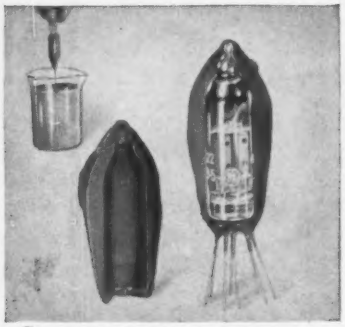
RAYTHEON COMPANY

INDUSTRIAL COMPONENTS DIVISION

RAYTHEON

CIRCLE 5 ON READER SERVICE CARD

General Electric RTV*
LIQUID SILICONE RUBBER



Cures at room temperature, useful from −70°F to +600°F

General Electric RTV silicone rubber compounds provide the dielectric properties of silicone insulation in a form well suited for potting, encapsulating, sealing and impregnating. Available in a wide range of viscosities from 120 to 15,000 poises, they do not shrink or form voids. RTV resists temperature extremes, moisture, ozone, weathering, aging and aircraft fuels. Applications include:

Potting and Encapsulating

RTV is used to pot whole electronic assemblies, while RTV encapsulation protects components from moisture, ozone, physical shock and high-altitude arc-over and corona. Also used as a conformal coating on printed circuits.

Transformer Impregnation

Impregnation with RTV assures top performance for aircraft transformers up to 250°C. Other materials failed due to poor high-temperature resistance or failure to penetrate tightly wound coils.

Cable Connection Potting

Connectors and junctions of high-temperature cable, such as missile wiring harnesses or industrial power and control cables in severe environment, are potted with RTV because of its ability to stand for long periods and then perform reliably when needed.

Longer Life for Motors

Electric motors last longer when stator windings are encapsulated with RTV. RTV's outstanding moisture resistance enables dripproof motors to meet certain applications which formerly required totally enclosed units.

*Room Temperature Vulcanizing.

For more information and a free test sample, write (briefly describing your application) to General Electric Company, Silicone Products Department, Section N930, Waterford, New York.

GENERAL ELECTRIC

COMMENT

Electronics Probes Nature

You are to be congratulated on your special report "Electronics Probes Nature" (p 53, July 29). It is authoritative, comprehensive and fascinating. I was particularly interested by the description of important research problems which are outside of my own field. It gives us a good appreciation of the great value of electronic instrumentation in furthering our understanding of our environment and of ourselves.

S. F. SINGER
UNIVERSITY OF MARYLAND
COLLEGE PARK, MD.

. . . I think the article is fine, but you may get letters about one statement that appears in my contribution. By a slight slip I am made to say that earthquakes occur only once in every five years. There are hundreds yearly, of course. What I said was that earthquakes of the terrific magnitude of the Chile earthquake have been happening on the average of every five years, which is a very different thing. If you get agonized letters of protest from geologists about this, you can perhaps insert a sentence of explanation in a future issue . . .

CHARLES H. HAPGOOD
KEENE TEACHERS COLLEGE
KEENE, N. H.

. . . The article was in most cases quite thorough and well done. Recognition of the importance of environmental probing as well as the role electronics plays in making this possible is most gratifying, and I hope your article receives commendation for its contribution . . .

ARNOLD M. MCCALMONT
USAF CAMBRIDGE RESEARCH CENTER
BEDFORD, MASS.

. . . You are to be congratulated for presenting so much that is new in this field in such a clear manner. I wish to thank you also for the kind reference to our efforts . . .

VON R. ESHLEMAN
STANFORD UNIVERSITY
STANFORD, CALIF.

. . . Looks very comprehensive and I'm sure will be interesting to the readers of ELECTRONICS . . .

MITCHELL KOZIKOWSKI
WESTINGHOUSE ELECTRIC
PITTSBURGH

. . . You have done an excellent job, both in collecting the many facts you needed to put a story together, and in preparing an interesting and informative presentation. I am sure that this review will be very valuable to industrial and government administrators, in showing the wide application of electronics in many new fields. At the same time, the working engineer and scientist will be pleased to see the place of his own specialization in the broad field.

My congratulations to you for the good work.

E. W. HEROLD
VARIAN ASSOCIATES
PALO ALTO, CALIF.

Manufacturers' Reps

Congratulations on the excellent article ("Manufacturers' Reps to Sell $2½ Billion," p 32) in the Aug. 26 issue of ELECTRONICS . . .

You have accumulated some most interesting figures, ones which I, at least, find to be most helpful and useful in many respects.

KENNETH E. HUGHES
KENNETH E. HUGHES CO.
UNION CITY, N. J.

The Missing Satellite

We enjoyed reading your fine August 26 issue. However, the column Washington Outlook on p 14 noticeably omitted Explorer VII from the list of satellites ". . . still actively transmitting."

Explorer VII, launched Oct. 13, 1959, by George C. Marshall Space Flight Center personnel before their transfer from the Army, has transmitted longer than any such fully instrumented satellite orbited to date.

BART J. SLATTERY
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
HUNTSVILLE, ALA.

NEW

ESC INTRODUCES MINIATURE VARIABLE DELAY NETWORKS ...SERIES 700

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702	.25 usec.	1800 ohms	.06 usec. (max.)
703	.50 usec.	1000 ohms	.10 usec. (max.)
704	.75 usec.	680 ohms	.15 usec. (max.)
705	1.0 usec.	560 ohms	.20 usec. (max.)
706	1.25 usec.	470 ohms	.25 usec. (max.)
707	1.50 usec.	390 ohms	.30 usec. (max.)
708	.65 usec.	93 ohms	.10 usec. (max.)
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*Minimum available delay at output
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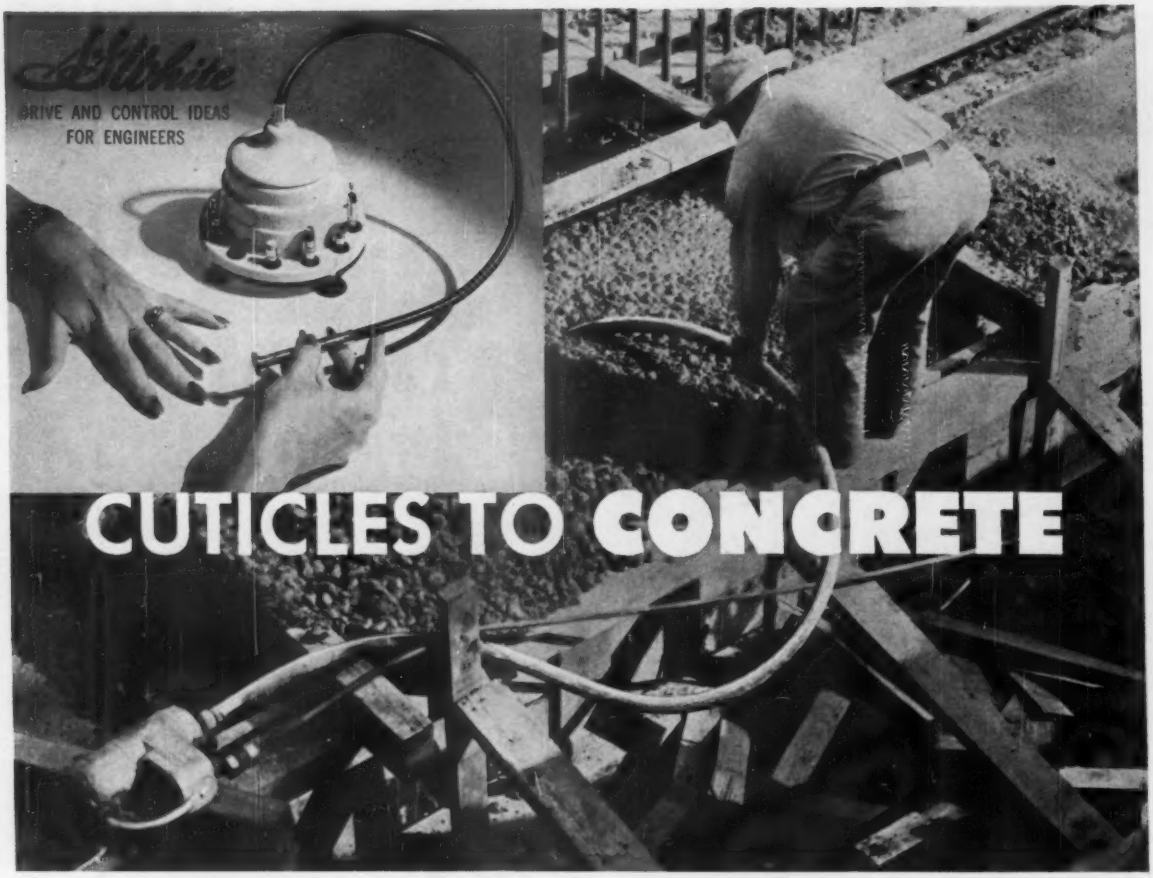

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10 East 40th Street, New York 16, N. Y.

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Working from 18,000 to 90,000 mc?

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Model:	Price:
K218	$ 500.
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E217	1650.

Just because you're working in millimeter bands is no reason to "make do" with lesser specs than you get from L to KU Bands. It's true that it's more difficult to maintain top specs at 90,000 mc than at X Band, for example, but in most cases Narda does it! And especially, in our slotted lines!

Precision instruments in every way, Narda millimeter Impedance Meters give you these important benefits: Smooth, stable carriage travel, absolutely parallel to the transmission line axis, with complete freedom from backlash. Imperceptible slope (0.01 max.), thanks to precision milling of tellurium copper main transmission line, followed by a silver plate of molecular thickness and a rhodium flash.

Residual VSWR is under 1.01 for K and V Bands; 1.02 for Q, M and E. Position of the built-in probe is measured with a precision dial indicator having a least count of 0.001". And as an added advantage, the probe is usable with any waveguide detector.

All in all, an exceptionally fine instrument — and yet, typical of all Narda millimeter products. For complete information on the entire line, write for a free catalog. Address: Dept. E-6.

Rely on narda *for these other precision millimeter products:*

Direct Reading VARIABLE ATTENUATORS
HARMONIC GENERATORS
High-Directivity DIRECTIONAL COUPLERS
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SLIDING TERMINATIONS
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STANDARD GAIN HORNS

the narda microwave corporation

118-160 HERRICKS ROAD, MINEOLA, L. I., N. Y. • PIONEER 6-4650

This unique "extra" fifth digit...
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KIN TEL
READOUT • MODEL
POWER
...provides 100% over-ranging...ten times greater resolution at decade voltage points where other 4-digit voltmeters change ranges and lose one full digit of resolution.
+18454

The KIN TEL Model 501 4-digit, over-ranging digital voltmeter measures DC from ±0.0001 to ±1000.0 volts with 0.01% ±1 digit (of reading) accuracy. An extra fifth digit in the left decade indicates "0" or "1" to provide ten times greater resolution at decade (1, 10, 100) voltage points than standard 4-digit voltmeters. Ranging and polarity indication are entirely automatic. The measured voltage, decimal point and polarity symbol are displayed on an in-line readout in a single plane–no superimposed outlines of "off" digits.

An adjustable sensitivity control permits decreasing sensitivity to allow measurement of noisy signals. Ten-line, parallel input printers can be driven directly, and converters are available for driving other types of printers, typewriters, and card or tape punches. The input may be floated up to 25 volts DC above or below chassis ground with no degradation in performance, and up to 250 volts DC with slight decrease in accuracy. Stepping-switch drive coils are energized with DC as in telephone-type service to provide long, trouble-free operation.

The 501 is one of a complete line of KIN TEL digital instruments. Others include AC converters, AC and DC preamplifiers, ratiometers, and multi-channel input scanners.

IMPORTANT SPECIFICATIONS

Display...Six decades display 5 digits (Left digit "0" or "1" only), decimal point, polarity symbol. Ranging and polarity indication are automatic. Projection system readout employs bayonet-base lamps with 3000-hour minimum life rating. Readout contains no electronic circuitry and can be remotely mounted.

Automatic Ranges...±0.0001 to ±1000.0 volts DC in four ranges: 0.0001 to 1.9999; 02.000 to 19.999; 020.00 to 199.99; 0200.0 to 1000.0

Accuracy...0.01% ±1 digit (of reading).

Input Impedance...10 megohms on all ranges at null.

Reference Voltage...Chopper-stabilized supply, continuously and automatically referenced to standard cell.

Stepping-Switch Drive...DC voltage within stepping-switch manufacturers rating applied by transistor drive circuit at rate of approximately 20 steps per second.

Controls...Three: on-off; sensitivity; and mode of operation (standby, normal, print auto, print remote).

Printer Drive...Built-in for parallel input printers. Automatic or remote.

Dimensions and Net Weights...Control unit: 45 lbs, 5¼" H x 19" W x 16" D. Readout: 10 lbs, 3½" H x 19" W x 9" D.

Price: $2995

KIN TEL manufactures electronic instruments for measurement and control, and closed circuit TV. Representatives in all major cities. Write for detailed literature or demonstration.

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ELECTRONICS NEWSLETTER

Probe Radiation Effects On Semiconductors

ALTERATION of semiconductor properties by means of ionizing radiation is being undertaken on a fairly large scale by several transistor manufacturers, according to reliable reports reaching ELECTRONICS.

Experiments on production quantities of semiconductors are reported. The research effort is being undertaken almost entirely by semiconductor manufacturers; advanced government research laboratories say they're not sure of what's going on.

Aim of the tests is to determine whether ionizing radiation can be used in place of the chemical and metallurgical techniques currently employed for surface treatment. Another aim is the transformation of basic electrical properties through deep penetration. Possible ultimate goal may be formation of semiconductor components from a single piece of homogenous material without alloying or diffusing other materials onto it.

Switching is among dynamic properties known to be affected by irradiation. Long-range effects are little known, which accounts at least in part for the industry's cautious and tight-lipped attitude. Experiments result in part from radiation-damage research done by various development labs in recent years.

Computermakers Set Up Sales, Service Accord

COMPUTERMAKERS National Cash Register and Control Data Corporation have completed negotiations on an agreement whereby CDC will supply a new type of low-cost computer and its related equipment to NCR. National will market the computer in the U. S. as part of its data-processing line for financial and retailing applications. Among other uses, NCR president Robert Oelman says, the CDC gear will be used as a controller for National's bank-bookkeeping equipment and magnetic-character ink document sorter.

In retailing, the computer will be sold to process the punched-paper tape produced by various types of NCR machines. Both NCR and CDC will market the computer abroad; CDC will also market it in the U. S. for engineering and industrial-control applications. CDC will market NCR peripheral gear —card-readers, paper-tape readers, output punches and printers— where these are needed by its computer customers.

The two firms are currently negotiating an additional agreement that will have NCR provide maintenance services for CDC's other computers excepting the big 1604. CDC would thus take advantage of NCR's service organization.

Silent Passive System For Underwater Detection

BUREAU OF NAVAL WEAPONS is buying $4.5 million worth of a new passive silent underwater detection system for submarines. The system is described as being extremely accurate, wide-range, compatible with existing fire-control equipment. It was developed under the aegis of Naval Ordnance Laboratory, checked out successfully in sea trials.

Navy spokesmen told ELECTRONICS they couldn't say it was or was not sonar. Informed sources indicate it may be the forerunner of a system which detects the existence of underwater targets by electrical or magnetic means.

Fed to Evaluate Bank Automation Systems

FEDERAL RESERVE BANK authorities, figuring that the U. S. proclivity for writing checks could soon swamp their facilities, have asked five electronics manufacturers to come up with an automation solution. Spokesmen for the Fed say check volume may reach 20 billion checks by 1963; the volume doubles about every seven years.

The Fed's main problem is to sort the floods of checks according to originating bank and to encode the dollar value of each check. Manufacturers preparing systems to do this include Burroughs, National Cash Register, IBM, National Data-Processing, and Pitney Bowes teamed with Ferranti-Packard.

All systems will use magnetic-ink character recognition and presume the common-language bank characters adopted by the American Bankers Association in 1958.

Mystery Satellite Still Unidentified

MYSTERY SATELLITE that was reported last Monday by Trinity University's Moonwatch team in San Antonio, Tex., is still a mystery. Space Surveillance Control Center told ELECTRONICS that it could not disclose the numbers or orbits of satellites under surveillance but not identified, leading to the speculation that there may be more than one.

Other reports admit the existence of a satellite "in retrograde orbit," moving in a direction opposite to the rotation of the earth. Trinity's report said the bright object—of magnitude minus five—was moving from south-southwest to north-northeast, which is the direct (as opposed to retrograde) motion of most Soviet satellites.

Smithsonian's space information center denies that any unidentified satellite is under surveillance. But reports persist that objects are up there which have not been reported by either U. S. or Soviet space authorities.

Minuteman to Have High-Reliability Parts

MINUTEMAN associated prime contractor Autonetics division of North American Aviation has awarded a subcontract to the Delco Radio division of General Motors for the development and operation of a reliability program for the transistors to be used in the missile. Goal of the program is a transistor success rate of 99.997 percent, equivalent to a quite respectable mean-time-between-failures for any equipment with 100 transistors or less.

NORTH ATLANTIC *industries, inc.*

SERVO DATA CONVERTERS

DC SERVO RATIOMETER
SBI 201/111

A miniature self-balancing servo indicator that provides direct readings proportional to the ratio of two DC voltages. Input signals can represent two variables or can be a single variable and its excitation source. In the latter application indications are independent of variations in excitation, thus permitting measurement accuracy significantly higher than with absolute measurement systems.

The SBI 201/111 is entirely self-contained and can be supplied to accommodate a wide range of signal inputs, with dial configurations to suit requirements. Optional features include: integral DC excitation source, retransmitting outputs and internal switching for signaling or control.

CONDENSED SPECIFICATIONS

Accuracy	±0.5% of f.s.
Resolution	±0.25% of f.s.
Excitation	typically 5V-50V DC
Range Sensitivity	10 mv., full scale
Response Time	0.25 sec. f.s. @ 28V DC excit.
Primary Power	115V, 400 cps, 25 watts max.
Input	any resistance type potentiometer or voltage source
Input Ranges (for E_1/E_2)	max. to min., 4:1 standard (typically 32V to 8V DC) Ranges to 10:1 on special order
Weight	3.5 pounds approx.

Designed for use with resistance type probes for measurement of total air temperature in aircraft flight testing, the FT-104D is a servo driven, self-balancing wheatstone bridge, entirely self-contained except for the probe. Its construction permits wide custom choice of measurement range, display and probe characteristics. In addition to one- or two-pointer visual display, it can be supplied with optional electrical outputs for telemetering, remote indication or recording. Available with internal DC excitation or can be used with external supply. Three-wire system permits accurate measurements with long leads between probe and indicator.

CONDENSED SPECIFICATIONS

Range	to user specification
Sensitivity	from 10 mv.
Accuracy	±0.5% of f.s.
Input (ohms)	50 to 10K standard
Calibration	optional relay-switched in-flight calibration resistors
Dimensions	3" dia. x 7" long (typical)

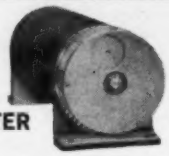
TOTAL TEMPERATURE INDICATOR
FT-104D

DUAL POINTER INDICATOR
SBI 205

Miniature panel-mounted position servo providing equivalent scale length of 3600°, for applications where high resolution, readability and dynamic response are important. Main dial 354°, vernier 360°, with 10:1 indication ratio. Accuracy ±0.1%, resolution ±0.05%, sensitivity 100 mv. f.s., full scale response less than 3 seconds. Optional single- or multi-potentiometer outputs, current output, control or signaling relays.

DIGITAL DISPLAY INDICATOR
SBI 301

Three- or four-digit counter display for highest readability and resolution. Range of available characteristics include accuracy 0.1%; scale range from 10^3 to 10^4 counts, full scale response from 3 to 5 seconds. Optional voltage and current outputs to suit system requirements. Can be supplied for measurement of either DC or AC signal inputs.



ANALOG TO DIGITAL CONVERTER
SBI 401

For use with pressure transducers, strain gages, accelerometers, thermocouples and other DC output transducers; provides non-ambiguous digital output for recording and data acquisition. Normally supplied with brush type encoders, but available also with magnetic or optical encoding assemblies to suit requirements. Basic dimensions 3" x 7"; full scale sensitivity 10 mv., response time from 2 seconds, depending upon encoder.

MODELS FOR SPECIAL APPLICATIONS

SYNCHRO REPEATERS. 2" and 3" o.d. repeater indicators for most 400 cps, BUORD size 8 thru 15 single speed synchro inputs. Wide range of speed, torque outputs. Ambients to 71°C., to 100°C. special. Models for 2-speed input on special order. For full data, write for Servo Requirements Sheet.

SIXTY CYCLE REPEATERS. For 60 cps operation in ground support, shipboard and industrial systems. Models to duplicate any of above 400 cps types, with same choice of inputs and outputs, almost identical operation and specifications. Comparable miniature size for space economy with no sacrifice in performance.

MINIATURE TRANSISTORIZED REPEATERS

Miniaturized repeaters for single- and dual-speed synchro, millivolt and resistance input. Case size from standard 2" O.D. down to BUORD size 15. Single- and dual-pointer displays; counter and encoder outputs where compatable with size requirements. Modular construction permits wide range of custom configurations for specific applications. Our engineering staff welcomes inquiries regarding special configurations and is available for consultation on your requirements.

Write or call for literature or quotations on your requirements

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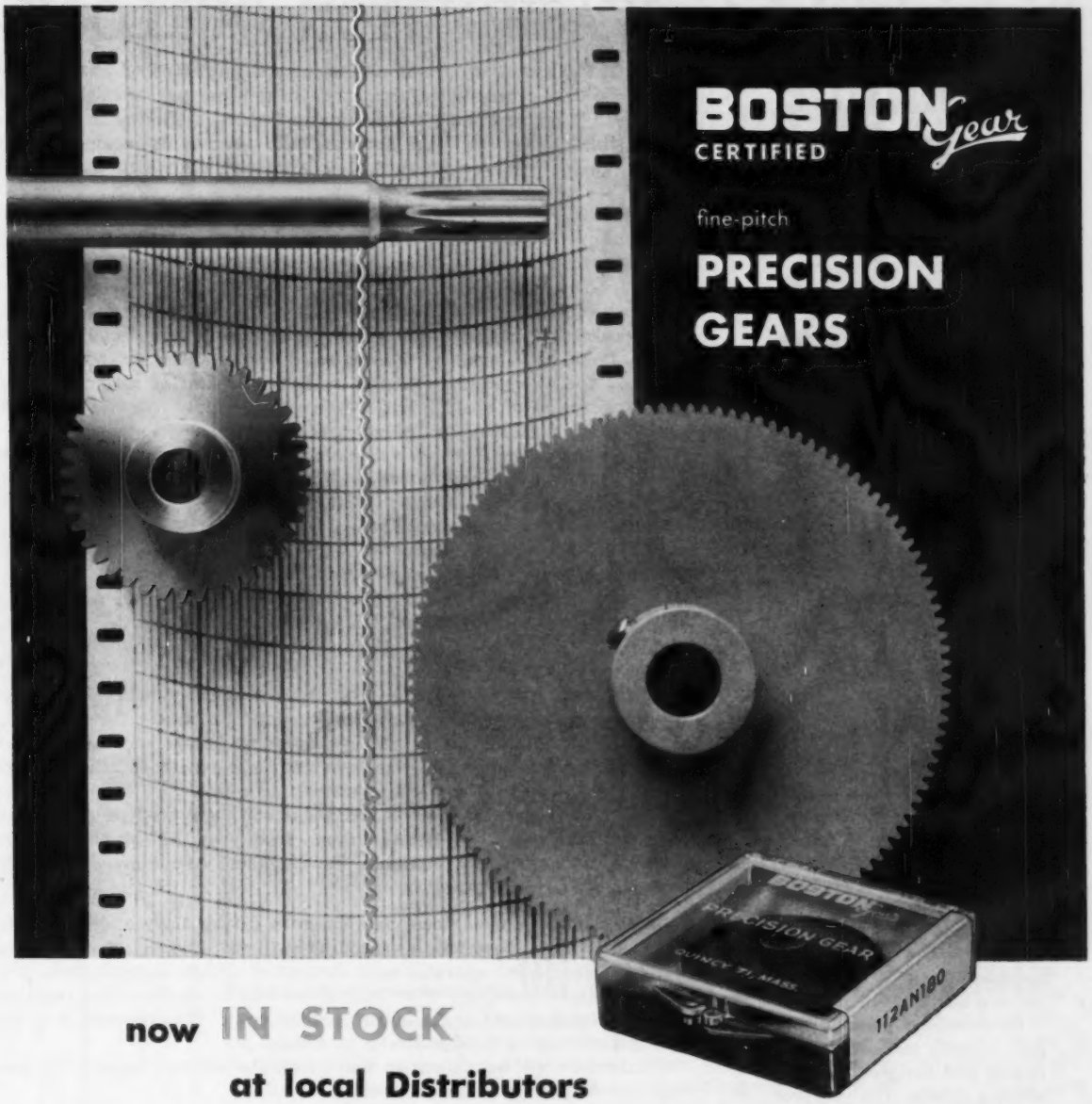

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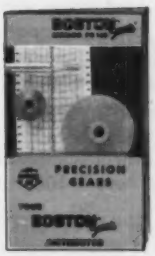

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PRECISION GEAR
Catalog PG 160

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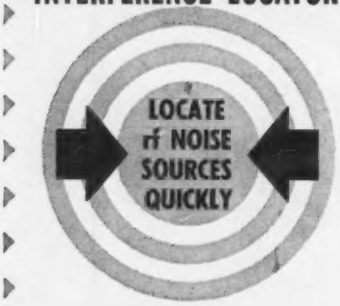
MODEL 500
INTERFERENCE LOCATOR



This versatile instrument is a highly sensitive interference locator—*with the widest frequency range of any standard available unit!* Model 500 tunes across the entire standard and FM broadcast, shortwave, and VHF-TV spectrums from 550 kc. to 220 mc. in 6 bands.

It's a compact, portable, rugged, versatile instrument—engineered and designed for most efficient operation *in practical field use.* It features a transistorized power supply, meter indications proportional to carrier strength as well as sensitivity of 5 microvolts minimum for 5% meter deflection over entire tuning range.

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WASHINGTON OUTLOOK

TOUGHER PENTAGON POLICY on the rental and purchase of business-type electronic data-processing equipment is in the making. Among the probable teeth in the new policy will be tighter Defense Department evaluation of feasibility proposals from agencies that want to use computers, and DOD "guidance," once a proposal is approved, on which machines to select.

For some time there has been criticism in the Pentagon that military agencies are going overboard on use of business-type computers. Anticipated operating savings from computers are not showing up in many cases.

A new report by the General Accounting Office, watchdog of the Pentagon's pocketbook, criticizes the Army's Transportation Materiel Command in St. Louis for installing a large-scale system. The project involved $300,000 for site preparation and an annual rental of about $360,000. After two years of operation, GAO charges, "supply operations (at the center have) not substantially improved."

GAO blames "the selection and installation of equipment not adequate for effective performance of the desired workload, and the failure to perform an adequate feasibility study and to correct underlying basic weaknesses in the supply system."

The accounting office wants the Pentagon to set "basic criteria for the selection of specific computer systems by military installations." A House Civil Service subcommittee has come out with a similar recommendation, calling for a central federal policy on computers, strengthened feasibility studies and a higher degree of standardization in federal use of data-processing gear.

Under the Pentagon's current system, the defense comptroller's data-systems research staff must approve agency proposals showing more economic operation or improved management before any agency can contract for a business-type computer. But for the most part the agencies are allowed to select their own machines.

This year the armed services will lease 455 business-type computers, paying a total rental of $83.8 million. Last year, 387 machines were rented at a cost of $61.7 million. Few business computers are bought outright by the military.

LOOK FOR more value-engineering clauses in future Navy and Air Force contracts. Contractors will be encouraged to set up special engineering staffs to "analyze or appraise each element of design, manufacture, procurement and installation of an item of hardware to achieve the required function specifications at the lowest possible cost." The purpose is to get the "goldplating" out of military contracts.

Contractors will be allowed to share with the military agency the savings resulting from value engineering.

Navy's Bureau of Ships, which has used value engineering for years in shipbuilding, is now pushing the concept in other areas of procurement, notably in electronics. Bureau of Naval Weapons and Army Ordnance are following suit, and soon the Air Force will be getting into the act.

The Bureau of Ships allows contractors to keep 50 percent of the savings. Policy of the other services is not so definite. In any case, value-engineering clauses offering financial incentives are considered the most suitable for fixed-price hard ware procurement covered by firm government specifications.

The new interest in value engineering is reflected in Electronic Industries Association's plan to hold a symposium on the subject in Anaheim, Calif., next Wednesday and Thursday.

DEFENSE DEPARTMENT will shortly release $8 million to the Navy for research and development in antisubmarine warfare electronics. This is a small chunk of the approximately $500 million tacked onto the defense budget by Congress but not yet released by the administration. Additional funds for Army electronics procurement may also be made available soon.

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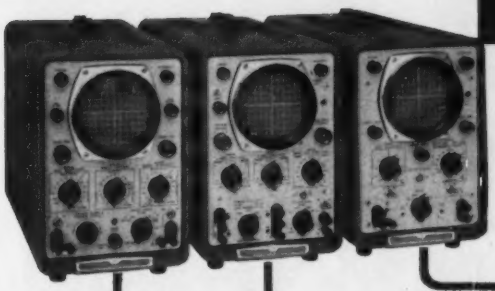
3 POPULAR hp OSCILLOSCOPES



Production or lab instruments—Simple to use, even for non-technical personnel—Moderately priced—Full 10 cm x 10 cm display—Automatic calibration waveforms—Low phase shift—Automatic triggering for optimum presentation—"Times-5" sweep expander magnifies trace, improves resolution.

DC to 200 KC

Models 120A/AR combine minimum controls with hp automatic triggering for utmost speed, convenience. Horizontal amplifier dc to 200 KC; phase shift only ± 2% to 100 KC. More X-axis information due to horizontal amplifier sensitivity control, with vernier, 5% accuracy. Balanced input on most sensitive ranges for low level work. Times-5 sweep expander, all ranges. 15 calibrated sweep speeds, 5 μsec/cm to 0.2 sec/cm. Vernier, expander extend speed range 1 μsec/cm to 0.5 sec/cm. 10 mv/cm sensitivity calibrated vertical amplifier, drift-free trace. hp 120A (cabinet) or hp 120AR (rack), $435.

DC to 200 KC – DUAL TRACE

Models 122A/AR provide simultaneous two-phenomena presentation, are ideal for direct comparison of filter, amplifier output/input phenomena; vibration testing. Unique hp front-panel automatic calibrator waveform switch. Twin vertical amplifiers operate independently, simultaneously, differentially. Automatic triggering, automatic synchronization, single trace operation when desired. Sensitivity 10 mv/cm to 100 v/cm, 15 calibrated sweeps, vernier extension. Horizontal amplifier dc to 200 KC. hp 122A (cabinet) or 122AR (rack), $625.

DC to 300 KC – "BIG SCOPE" PERFORMANCE

Models 130B/BR provide wide usefulness, simple operation and rugged dependability. 21 calibrated sweep times, 1 μsec/cm to 5 sec/cm. Vernier, expander extend range 0.2 μsec/cm to 12.5 sec/cm. Twin horizontal and vertical amplifiers, phase shift ± 1° to 50 KC; sensitivity 1 mv/cm to 125 v/cm. Balanced input on 6 most sensitive ranges. Common mode rejection 40 db. Stability 1 mv/hour after warmup. Triggering automatic, internally, line power, externally, 0.5 v or greater. hp 130B (cabinet) or 130BR (rack), $650.

Data subject to change without notice. Prices f.o.b. factory.

Thirteen precision hp oscilloscopes, dc to 1,000 MC

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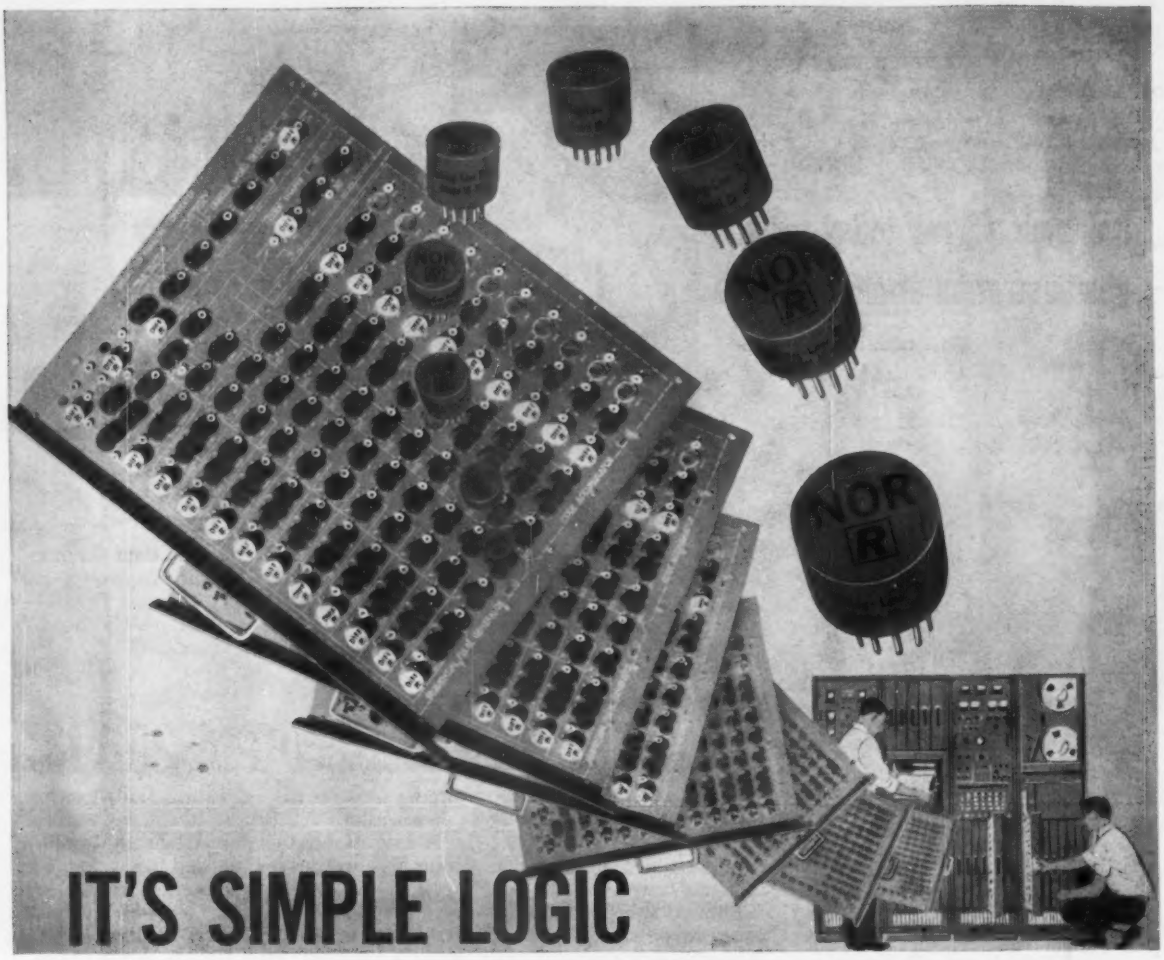

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"Radilogs" are small plug-in logic modules that make possible entire digital systems, using a repetition of as few as two basic circuits. Maintenance involves consideration of only two parameters, saturation and cut-off. Simple rearrangement of a group of "Radilogs" produces entirely new configurations of logic networks. Thus, many a costly system that has served its original purpose is saved from obsolescence. New systems can be designed for greater simplicity and versatility at lower cost.

Radiation developed and presently offers "Radilogs" in three circuit configurations: NOR, Differentiator and Power Driver. Each of these is available in three speed ranges: low, medium and high. Encapsulated and color-coded, they plug into standard 9-pin miniature tube sockets.

For technical information and prices, write to Radiation Inc., Dept. EL-9, Melbourne, Fla.

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TDMS – Telegraph Distortion Monitoring System pinpoints type and source of trouble on teletype, data processing and similar communications links without interrupting traffic. Ultra-compact TDMS can replace most test equipment now required for teletype maintenance and monitoring.

RADIPLEX – 48-channel low-level multiplexer with broad data processing applications. Features rugged solid-state circuitry, almost unlimited programming flexibility, unique modular construction for compactness and exceptional ease of operation and maintenance.

TELEMETRY TRANSMITTER – Model 3115 is a ruggedized 215-260 MC unit with extremely linear FM output under the most severe environmental conditions. With its record of outstanding performance in many missile programs, Model 3115 is specified by leading missile manufacturers.

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NEW! ®Resinite Vinyl Glass

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Owens-Corning Fiberglas Corp.

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An insulation you can flex ...twist...pound...vibrate ...heat...soak with oil

This is a completely new insulation that can take every abuse listed above without cracking, crazing or loss of its high 8,000 volt electric strength. Resinite is a vinyl-coated Fiberglas* sleeving that surpasses all NEMA standards.

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- Better color stability and smooth, clean surface texture.
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- 8,000 volts min. dielectric rating. Also 4,000 and 2,500 volt grades.
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Graphite Facts

by George T. Sermon, President
United Carbon Products Co.

Purchasing Policy... and Russian Roulette!

Management policy decisions sometimes seem somewhat like Russian Roulette. For example:

"Three competitive bids will be obtained. The company submitting the lowest bid will be awarded the purchase order. Under unusual circumstances, the second lowest bidder will be chosen and a letter of explanation submitted to the president."

Sound familiar? And, in five of six purchases, this policy is as harmless as the unloaded chambers of a revolver used in Russian Roulette. However, there's always a good chance that an order placed *according to policy* can be a major disaster. Since your Purchasing Agent is human, he will feel he's doing his job best by shopping for *price*. There's the danger . . . *policy* replaces *judgment*.

I have seen this happen time and again in the rapidly growing semiconductor field. Graphite boats will be purchased because of a small price advantage (a matter of policy) without regard for: ability to deliver future orders of consistent quality; breadth of experience which could help solve or circumvent production bottle-necks; capacity to meet the future potential of your own product; financial soundness and business responsibility.

When you buy a United product, you get all of this. It's our policy.

UNITED carbon products co.

BOX 747 BAY CITY, MICHIGAN

FINANCIAL ROUNDUP

Ampex Plans New Merger

BOARDS OF DIRECTORS of both **Ampex Corp.** and **Telemeter Magnetics, Inc.,** Culver City, Calif., have adopted a resolution recommending merger of Telemeter into Ampex, subject to approval by shareholders of both companies. Merger will be on the basis of one Ampex share for two shares of Telemeter. The proposal will be submitted to the two shareholder groups at meetings slated for later in the year.

Reported acquisition of **L. C. Miller Co.** by **ITT** (ELECTRONICS, p 20, Sept 9), was erroneous. The purchase was of the vibration testing equipment developed by Miller. The sale involved only a minor portion of L. C. Miller assets, according to company president L. C. Miller, and the company is expanding facilities to meet customer requirements and to further development programs on induction heating equipment and related items.

Magnetics Inc., Butler, Pa., producer of electronics components, reports purchase of **Kemco Corp.,** industrial control panel manufacturer, Sandy Lake, Pa. Purchase was through exchange of stock whereby one share of Magnetics was exchanged for 3-1/16 shares of Kemco, plus cash to cover fractional shares. Kemco shareholders will divide 5,109 shares of Magnetics, or about $62,580 worth of stock.

D. S. Kennedy & Co., Cohasset, Mass., reports sale of $1 million in 5½-percent debentures with warrants attached. The placement was a private one negotiated by E. F. Hutton & Co. The debentures are subordinated to short-term bank loans. One half of the issue is due Sept. 1, 1963, the other Sept. 1, 1965. C. F. Mooney, Kennedy president, says the additional capital is needed to finance expanding business.

Alloyd Electronics Corp., Cambridge, Mass., announces the sale of $400,000 of its eight-percent convertible debentures to Electronics Capital Corp. The debentures are convertible into 45 percent of Alloyd's total common stock. The Massachusetts firm is engaged in research and development of electron beam equipment for vaporizing, refining and welding metallic and ceramic elements. This is ECC's 12th such investment.

Daystrom, Inc., Murray Hill, N. J., reports filing of a registration statement with Securities and Exchange Commission covering a proposed offering of $10 million sinking fund debentures, due Oct. 1, 1980. Interest rate and offering price will be announced later. Goldman Sachs & Co., and R. W. Pressprich & Co. head a group of underwriters planning to offer the securities. Proceeds from sale of the debentures will be used to replenish and increase working capital. The sinking fund will provide for retirement on April 1, 1964 through 1980, in-

25 MOST ACTIVE STOCKS

WEEK ENDING SEPTEMBER 16, 1960

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Ampex	1,173	28⅝	26⅜	28
Universal Control	1,035	18⅞	17⅛	18⅛
Avco Corp	910	15¾	14¾	14¾
Gen Dynamics	883	40¾	38¼	38¾
Gen Tel & Elec	835	29¼	28¼	28⅜
Collins Radio	595	57¾	51¼	51¼
RCA	565	59¾	56⅛	56⅜
Elec & Mus Ind	559	7⅜	6⅞	7
Gen Electric	525	80¾	78	78¼
Sperry Rand	423	21¾	21	21
Gen Instrument	409	39½	36	36⅜
Zenith Radio	396	125½	118¼	120
Beckman Inst	376	98½	91¾	92¾
Westinghouse	371	53¼	50½	51
Texas Inst	353	197⅞	183¼	185¼
Varian Assoc	328	50⅜	45¼	45⅜
Int'l Tel & Tel	322	40¾	38⅛	38¼
Telectro Ind	311	20½	18⅛	19
Reeves Sndcrft	294	8¾	7½	7⅝
Sterling Precis	290	2⅞	2⅝	2⅝
Bulova Watch	288	21½	19¼	20
Standard Kollsman	285	24¾	22⅜	23¼
Polarad	275	28⅜	26⅝	27⅜
Heli-Coil	269	50¼	43¼	43½
Litton Ind	264	82	76⅜	76⅜

The above figures represent sales of electronics stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for ELECTRONICS by Ira Haupt & Co., investment bankers.

clusive, of not less than $470,000 nor more than $940,000 principal amount of indebtedness.

Negotiations on the merger of **Milo Electronics, Inc.**, New York, into **Newark Electronics Corp.**, Chicago, have been agreed to in principle, according to a joint statement by the two firms. Although exact terms are not disclosed, the merger would be effected through an exchange of stock with all of Milo's shares being traded for an undisclosed number of Newark shares. In the fiscal year ended Aug. 31, Newark sales were about $12 million. Milo's annual volume last year was about $5 million.

Magnetic Control Co., Inc., Minneapolis, announces successful completion of a $700,000 offering of stock. The 233,000-share issue marks the first time in the history of the eight-year old company that the stock has been publicly traded. Completion of the sale brings the total shares outstanding to 1,743,600, with another 381,400 shares authorized but not issued.

Automation Industries, Manhattan Beach, Calif., manufacturer of magnetic ultrasonic and missile structural products, announces a 24-percent increase in sales for the six months ended June 30, 1960. Consolidated sales for the first half were $1,913,010, compared with $1,538,512 for the same period a year ago. Consolidated earnings were $153,364 on 1,048,631 shares outstanding. This includes $66,770 derived from the sale of patent rights and $10,000 from the company's Industrial Leasing division.

Small Business Administration announces prime military and civilian government contracts valued at $91,356,047 went to small concerns during July of this year as a result of SBA efforts. Total contracts awarded during the month numbered 2,438. Of these, 1,872 were military, 566 civilian. SBA men also were able to earmark $115 million in proposed spending for small companies. Military total was $99.4 million, civil, $15.1 million. The funds were set aside with help from civilian agencies.

the first complete line of TRANSISTOR VOLTMETERS . . .

6 ALL-TRANSISTOR MIL TRVMs

- miniature, panel-mounting, for build-in applications
- power supplies included—no battery replacement or checks needed
- isolated inputs • low power consumption
- compact (as small as 2.85" diameter by 6" deep including terminals)
- lightweight • longer life

Model	Meter	Description	Price
301-1 AC TRVM	3½"	zero-left, from 10MV range	$250.00
302-1 AC TRVM	3½"	zero-center, phase sensitive, from ± 10MV	275.00
303-1 AC TRVM	2½"	50% less panel area than Model 301-1	275.00
304-1 AC TRVM	2½"	zero-center, phase sensitive, from ± 10MV	300.00
305-1 DC TRVM	3½"	zero-center, no zero-set, ± 100MV range	225.00
305-2 DC TRVM	3½"	zero-left version of 305-1, 250MV range	225.00

Note: Due to heavy demand, present delivery of most models is 6-8 weeks. For complete literature, write to Dept. E-9.

. . . when ordinary instruments are too big or inadequate.

trio

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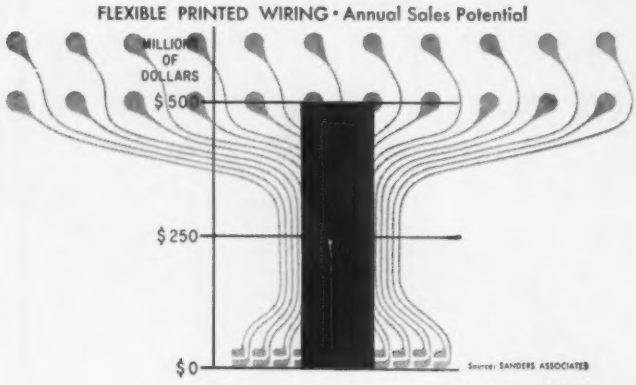


Flexible Printed Wiring Sales to Rise

FLEXIBLE PRINTED WIRING sales to the electronics industry will reach $500 million annually, according to Royden Sanders Jr., president of the New Hampshire company which introduced a Flexprint system two years ago. No timetable was set, but it is expected that it will take at least 10 years to reach that sales figure.

Demonstrating a four-pound flexible printed wiring system which replaces a 56-pound wired harness for missiles. Sanders told the Society of Security Analysts in New York that flexible printed wiring also has a promising future for wiring electric ranges and automobile electrical systems.

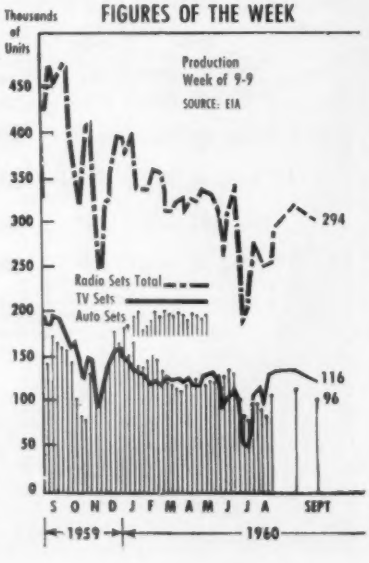
Many companies are already designing flexible printed wiring into new products to be automated and the telephone industry has begun an exhaustive series of tests, he said.

Military electronic equipment manufacturers can expect lower growth rates in future, Electronic Industries Association reports. The phenomenal yearly market expansions of 15 to 25 percent since the Korean war will slow down to 8 to 10 percent in the next five to ten years, members were told at the association's annual fall conference.

Position taken by EIA was based on an opinion survey among more than 50 military marketing experts on the Military Marketing Data Committee, which is headed by L. H. Orpin, manager of defense planning for RCA.

Reasons given for the slowdown by EIA are reduced aircraft expenditures, the near completion of the national air defense system and the concentration by the military on few, rather than many, major missile systems.

Expected slowdown will not affect all products, the committee indicated. Areas where future prospects are promising include ballistic missile defense, so-called exotic weapons, surveillance systems, communications systems for the control of combat forces and intelligence operations, and the application of electronics to civil defense.



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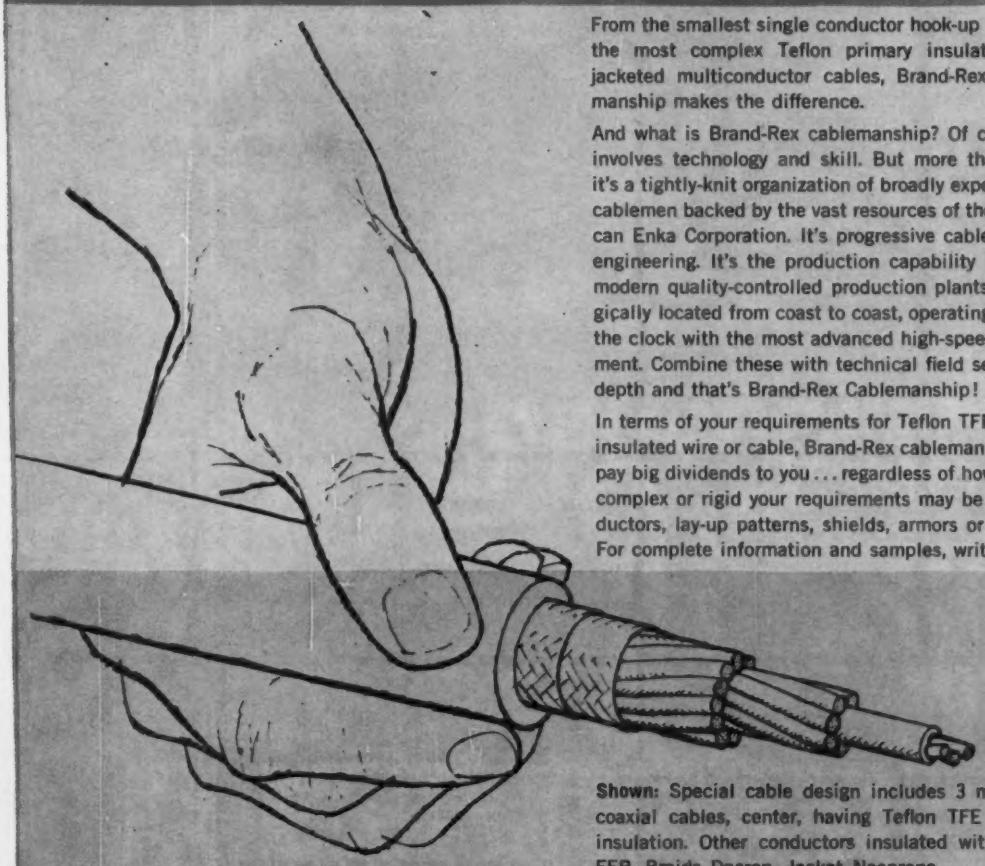

Shown: Special cable design includes 3 miniature coaxial cables, center, having Teflon TFE primary insulation. Other conductors insulated with Teflon FEP. Braids Dacron. Jacket Neoprene.

Left: Cables can be furnished with individual coaxials, pairs, triples or other components positioned within the cable exactly to specs. **Center:** Brand-Rex coaxial cables use Teflon dielectrics and meets all government and commercial requirements. **Right:** Brand-Rex quality-control procedures cover every step of manufacture.

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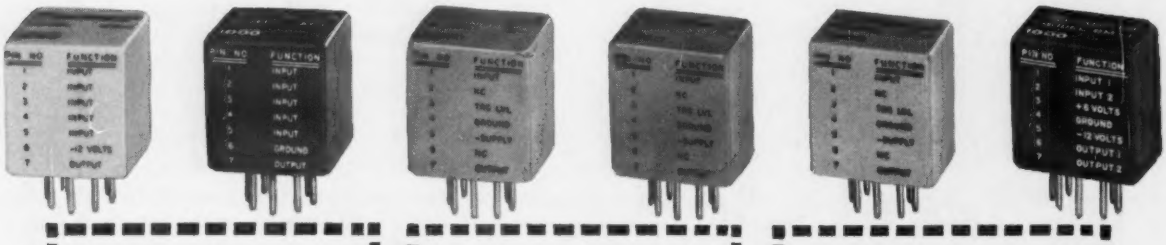

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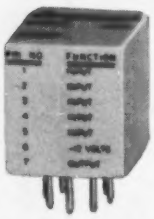

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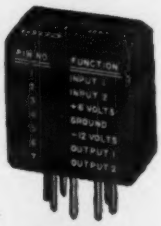

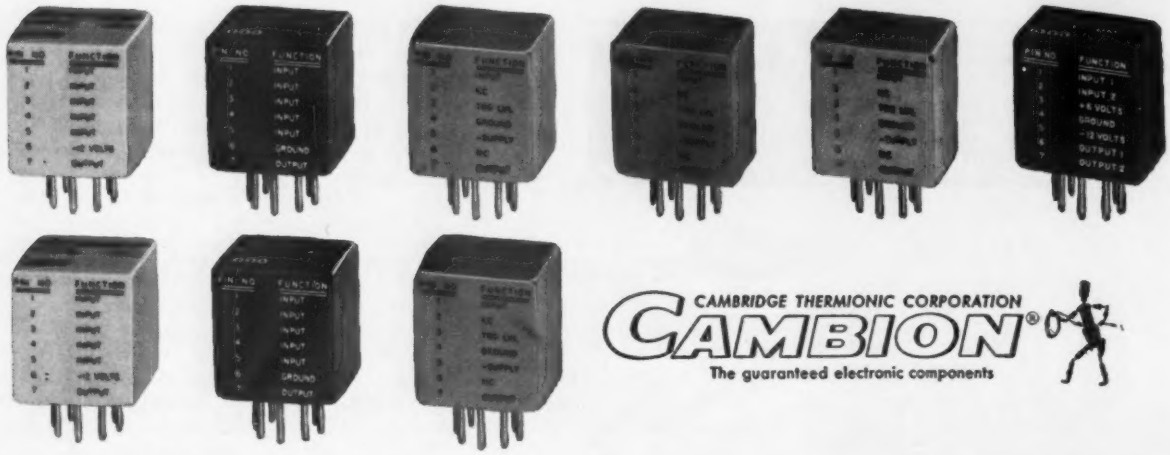

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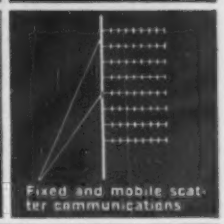
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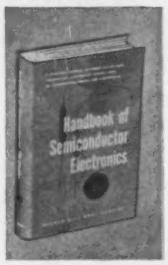

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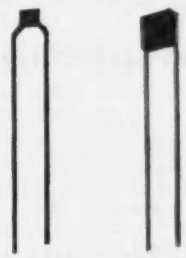

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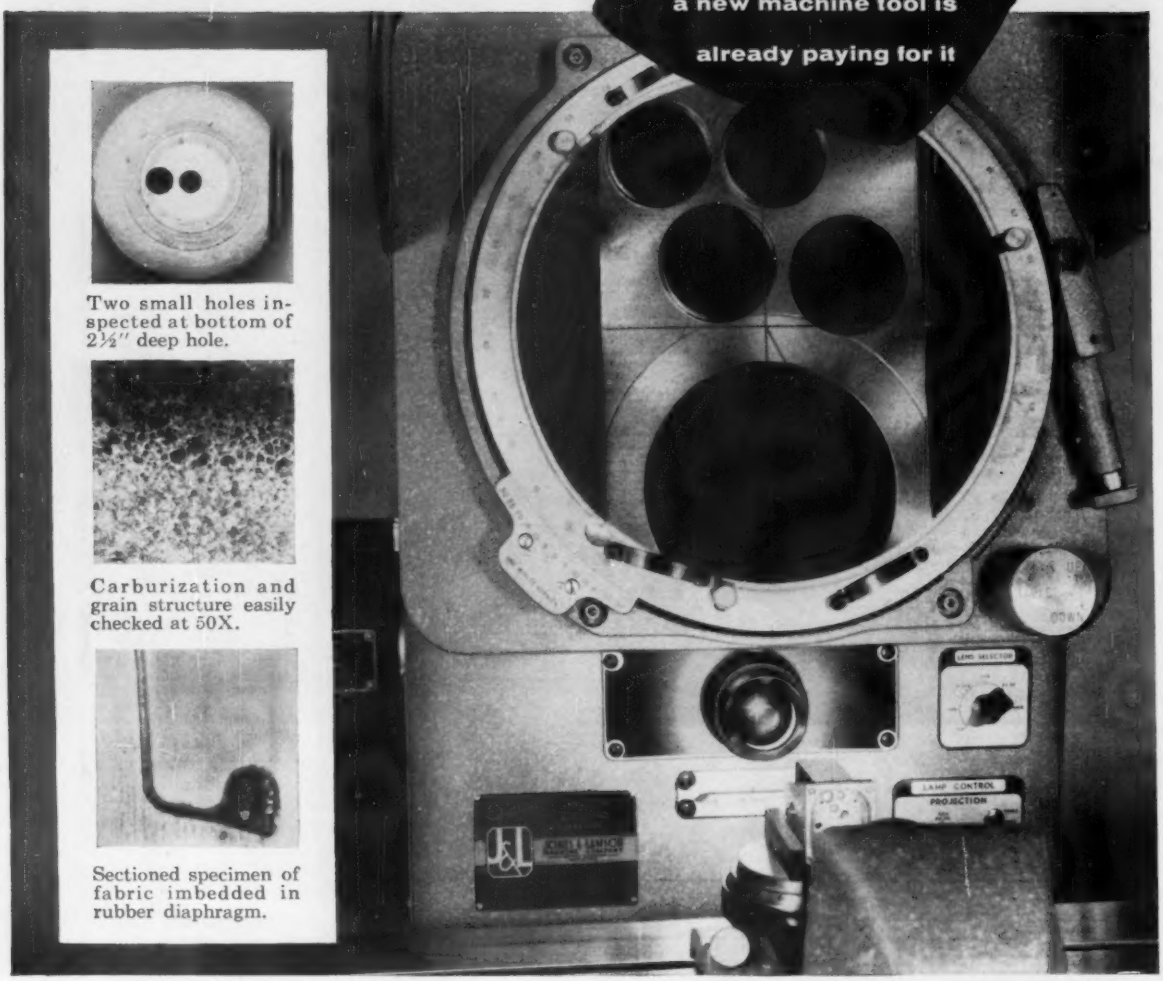

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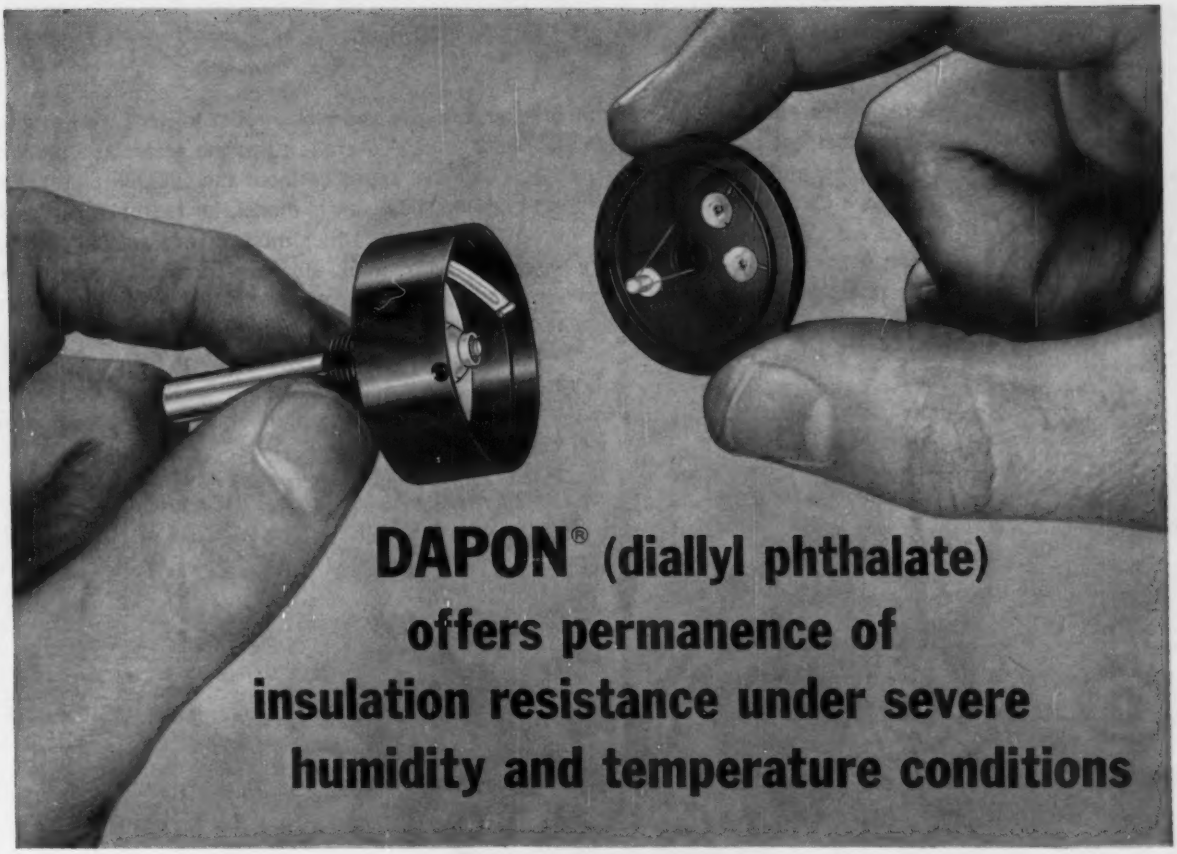

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This plastic is ideal for applications where changes in humidity can affect electrical values. DAPON can prevent costly "in service" failures in electrical and electronic components.

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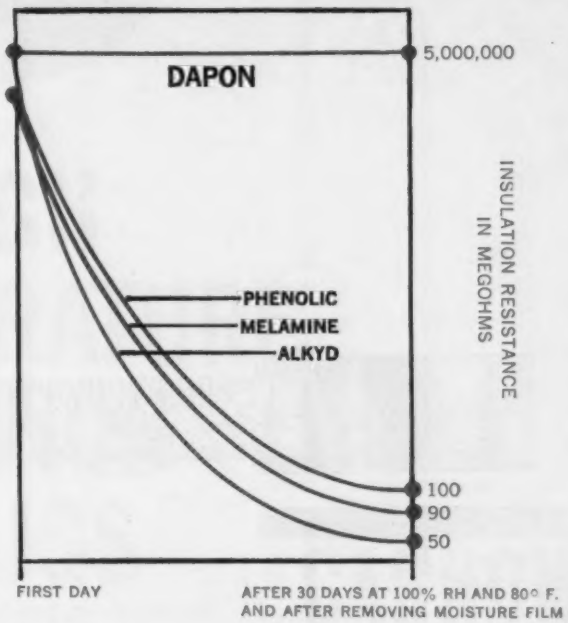

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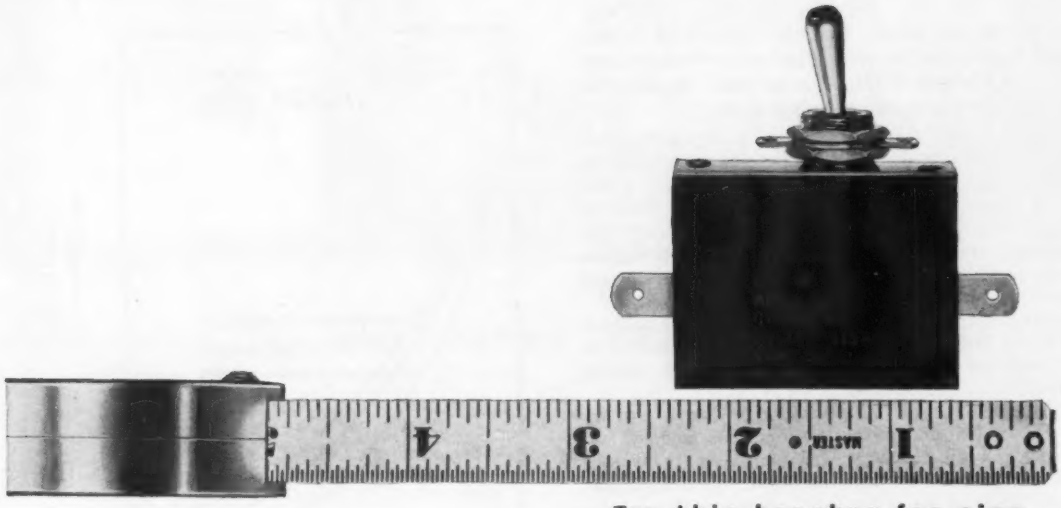

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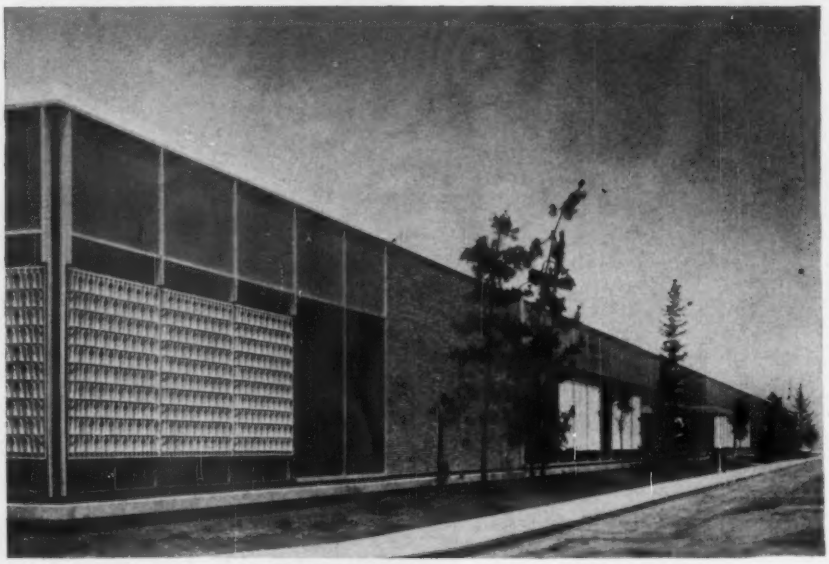
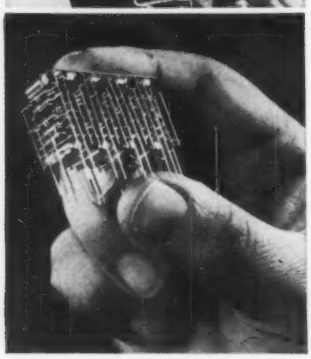


Merritt MacKnight, Manager, Systems Development Department, demonstrates the sophisticated design of a Litton digital computer assembly for the new Grumman A2F.



Welded wire techniques substantially increase component packing densities.

This 180,000-square-foot building is the first unit of a facilities complex which eventually will comprise 825,000 square feet in the Los Angeles suburb of Woodland Hills, California. This facility of the Electronic Equipments Division of Litton Industries is designed for maximum convenience, comfort, and efficiency.

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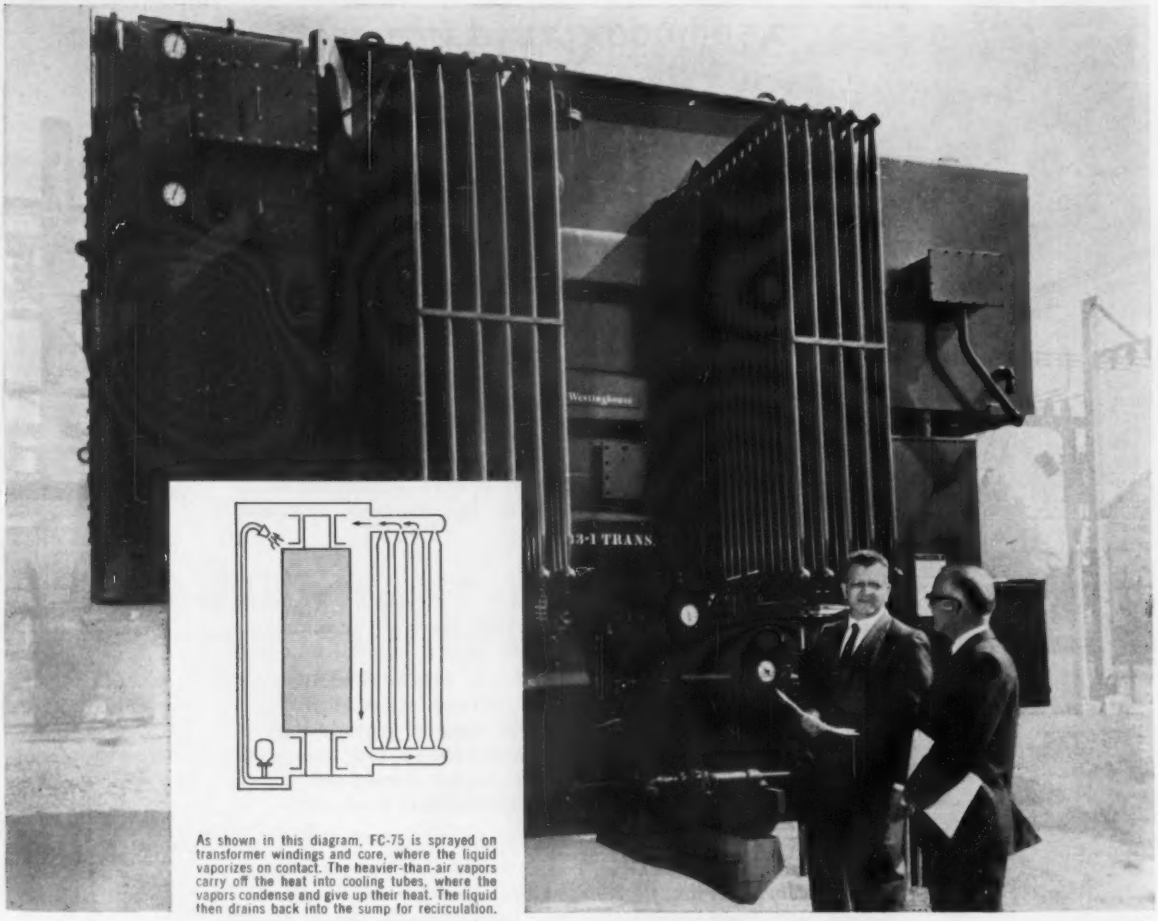

As shown in this diagram, FC-75 is sprayed on transformer windings and core, where the liquid vaporizes on contact. The heavier-than-air vapors carry off the heat into cooling tubes, where the vapors condense and give up their heat. The liquid then drains back into the sump for recirculation.

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Even indoors in residential and downtown areas, nonflammable, non-explosive FC-75 permits the installation of high voltage transformers with none of the stringent fire precautions required for conventionally cooled units . . . and none of the expensive maintenance. Here FC-75 as a vapor coolant makes firewalls, drainage pits, sprinkler systems obsolete.

Westinghouse engineers chose 3M Brand Fluorochemical FC-75 as coolant for important reasons: its high electric strength of 37 KV at one atmosphere in both liquid and vapor state; its self-healing in high voltage electrical equipment after repeated arcing; the quieter operation because transformers are self-cooled at 100% load; and maintenance of coolant, core, and coils is practically nil.

The 3M family of fluorochemicals have many and versatile applications in the field of electronics. They are non-explosive, nonflammable, nontoxic, noncorrosive, and odorless. Consider them in terms of your product problems. Write for information on your company letterhead, specifying product interest: 3M Chemical Division, Dept. KAX-90, St. Paul 6, Minnesota.

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CIRCLE 35 ON READER SERVICE CARD→

New from Polarad

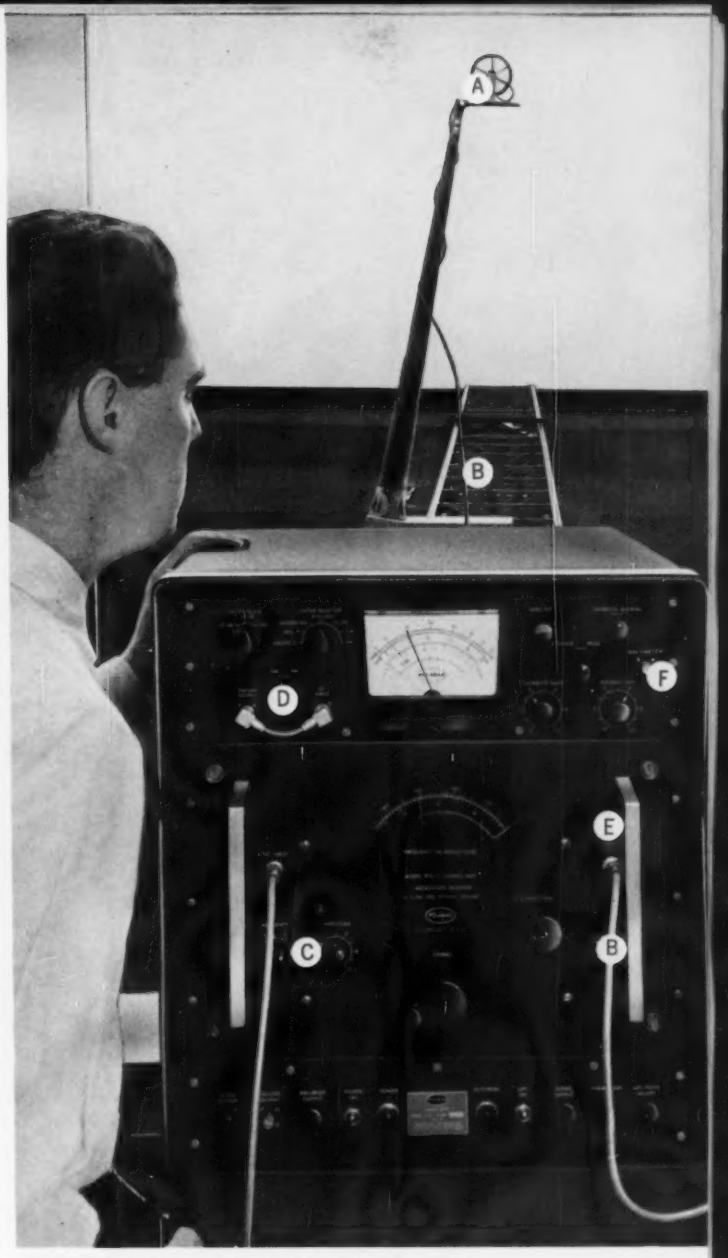
ANTENNA PATTERN MICROWAVE RECEIVER

ULTRA-BROADBAND COVERAGE

2,000 to 75,000 mc in a single unit

- **A External Mixer.** May be located at or near antenna, any distance up to 75 feet from receiver.
- **B Flexible cable connects mixer to receiver.** Eliminates cumbersome rigid waveguide.
- **C Internal electronic 1000 cps sweep** allows direct operation into any standard make AC antenna pattern recorder.
- **D CW, AM, FM and pulse reception.**
- **E Sensitivity.**
  2 kmc to 10 kmc....–85 dbm.
  10 kmc to 35 kmc....–80 dmb.
  35 kmc to 75 kmc....–70 dbm.
- **F Linearity** maintained over 40 db dynamic range.

The Model RW-T is another example of the versatility of the well known Polarad Model R Microwave Receivers. The RW-T is excellent to measure antenna gain, pattern, minor lobes, front-to-back ratio, SWR and bandwidth.



Model RW-T Microwave receiver being used to make antenna pattern measurements on Polarad range.

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POLARAD ELECTRONICS CORPORATION:

Please send me information and specifications on:

POLARAD

- ☐ Model RW-T Antenna Pattern Receiver
- ☐ Model KSS Microwave Power Source (see reverse side of page)

My application is_____

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New from Polarad

COMPACT MICROWAVE POWER SOURCE

1,050 to 11,000 mc 4 PLUG-IN UNITS

Model KSS Power Source being used to make antenna pattern measurements on Polarad Antenna Range. Can also be used for minor lobes, front to back ratio, SWR and gain measurements.

The new Polarad Model KSS features an advanced modulator design that provides CW, FM and internal square wave (10 to 10,000 pps). External pulse capabilities permit rise times to 0.15 μsec. The unit has an adjustable attenuator and low incidental AM and FM at relatively high power.

Ⓐ Basic unit (HU-4) includes modulator and power supply into which is plugged any one of four R-F tuning units Ⓑ that cover the frequency range 1,050 to 11,000 mc. Tuning units are equipped with UNI-DIAL control Ⓒ that automatically tunes klystron cavity with reflector voltages.

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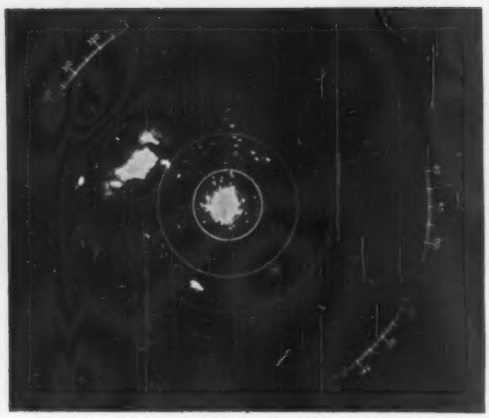
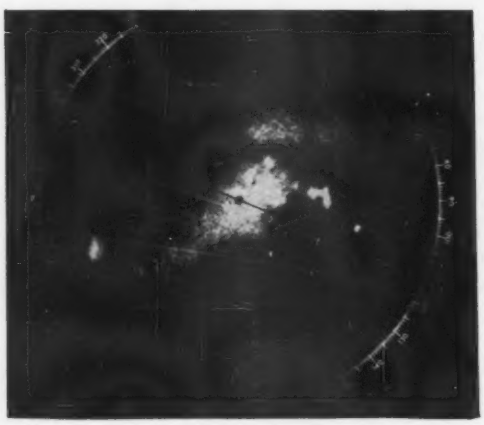
USWB map shows present status of growing weather radar network

WEATHER RADAR

$3 million in electronic equipment, the



Center of hailstorm as spotted by WSR-57 radar (top) and expanded for study (right) on ppi scope



SOMETHING *is* being done about the weather. Especially hurricanes.

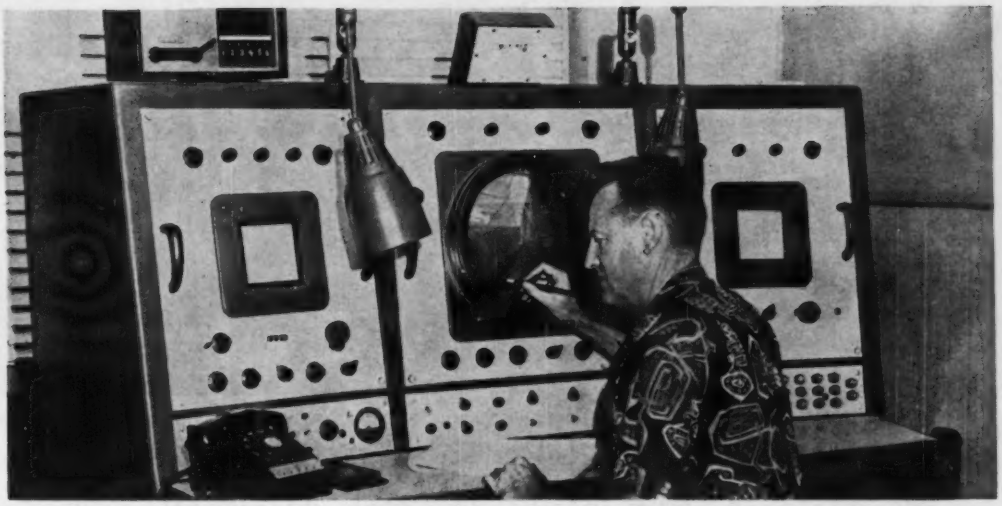
This week U. S. Weather Bureau technicians are working hard to meet the Jan. 1961 deadline for completion of a $3,800,000 weather-search radar net begun a year ago.

Started in Miami, Fla., in June last year, the latest score for the major radar system, termed the WSR-57, is 17 installations completed, two more in the preliminary state, and 12 stations having older equipment to be updated with WSR-57 gear.

Able to detect minor rainfalls at 200 miles and hailstorms at 220 miles, the completed network will blanket the U. S. Atlantic hurricane coast, regions of the midwest and great plains tornado areas, and other strategic locations.

In commenting on this latest weapon against storm damage, F. W. Reichelderfer, chief of the Weather Bureau, says the equipment is designed to operate over extended periods in a wide variety of climatic conditions.

The WSR-57 presently operates in the 2,700-2,900 Mc band. It is designed to allow a change in frequency to the 5,600-5,650 or 9,300-



Operator at a Florida hurricane tracking station checks storm path

NET NEARS COMPLETION *Representing more than*

nation's newest weather network will blanket crucial storm areas round the clock

9,500 Mc bands by changing the transmitter package on the antenna and the r-f feed at a later date.

Peak operating power at present frequencies is 500 Kw. Raytheon, manufacturer of the equipment, says it has completed 31 sets for the Weather Bureau and eight additional sets for the Navy's Bureau of Weapons.

The antenna used with the WSR-57 is a single 12-ft parabola with r-f feed system. The transmitter, receiver and duplexing network are all mounted on the antenna along with the directional coupler and noise generator (used for system tests).

The radar is controlled from a console furnishing video outputs, as well as operating controls, monitors and associated circuits. A picture of what the antenna is receiving is available on an rhi scope, A and R scope and two ppi scopes, one for direct and one for off-center viewing.

The rhi indicator presents range information on the horizontal axis, height on the vertical axis. Weather bureau men describe it as a rectangular display. It is shown on the face of a 7-in. crt. This display also shows the azimuth of the antenna.

An ancillary use of the weather network will be flood forecasting as a factor of rainfall studies. Each installation is being provided with a photographic repeater to gather data. These repeaters photograph the ppi scope simultaneously with a series of indicators which show the operating state of the radar.

Weather bureau officials say the maximum range of the equipment is 250 nautical miles, with provision for measuring height up to 70,000 feet. The antenna rotation rate is variable from zero to four rpm, and the antenna can be tilted in elevation from minus 10 to plus 45 degrees.

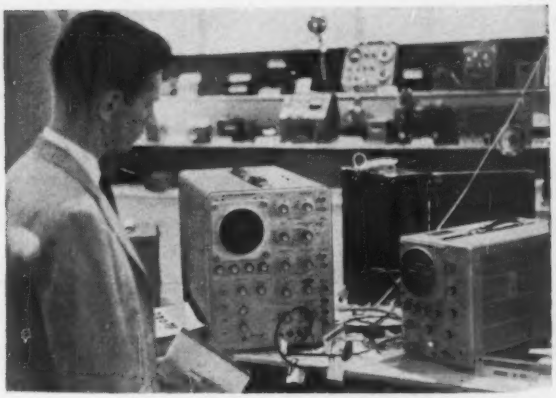
Some indication of the importance the Weather Bureau is attaching to the new network is the fact that a special course was established last year for WB personnel at the University of Miami for the men who will work the equipment. The four-week sessions provide a background in the fundamentals of the radar circuit, radar meteorological theory and the operational techniques of applying radar to weather forecasting. To date more than 200 men have been trained.

Ultimate aim of the Weather Bureau is a central location where all weather data from the radar networks will be processed hourly to provide a large-scale picture of the weather situation. One prediction is that all weather radar stations in the country (see map) will be joined in such a network within ten years.

Paralleling the growth of the government network has been a marked increase in privately owned weather radar gear operated by broadcasters. Of particular interest in storm-conscious regions of the country such as the midwest and the Florida coast are the displays tv broadcasters provide.

Most of the tv radar installations, and there are now several dozen in the country, operate in the spectrum around 5,400 Mc. Among the suppliers of equipment to broadcasters are Collins Radio, Bendix and RCA.

Work now in process will permit assembly of composite weather maps made up of radar photographs taken simultaneously throughout the network and relayed to key weather centers by facsimile hookups.



Laboratory instruments (at left, in New York) and industrial controls (right, in Moscow) are newest entries in Japan's worldwide search for new business

Japan Probes Instrument Market

New York show is trial balloon to determine U. S. reaction. Earlier Moscow show probed Soviet reaction

JAPANESE INSTRUMENTMAKERS have begun their long-awaited probe of the American market.

First step was the Japan Precision Measuring Instrument Show, which opened at the Japan Trade Center in New York at midmonth and just closed. Exhibiting there were 27 of the 81 members of JEMIMA, the Japan Electric Measuring Instrument Manufacturers Association.

The show followed by a week another exploratory probe on the part of Japanese manufacturers of capital goods. At Moscow's Sokolniki Park, Japanese businessmen put on an industrial exhibition which saw the sale of virtually every piece of machinery and equipment on display. Moscow observers comment that despite the shelf-cleaning, there were some questions as to how profitable the whole thing was for participating firms.

The New York show was more specific than the exhibit at Sokolniki Park. It was dominated by fairly standard types of instruments for measuring electrical parameters, ranging from ammeters and frequency meters in the power-frequency range to synchroscopes. Some industrial process-control instruments were on display, and some high-precision types of ter-ohmmeters and picammeters.

In an exclusive interview, JEMIMA managing director Tetsuo Horiguchi told ELECTRONICS that the exhibit "will be used to diagnose the reaction of the American market. If the reaction proves good, then the problems of price, service, spare parts and marketing will be investigated."

In sending up this trial balloon, the Japanese manufacturers are facing head-on the unfavorable reactions generated in the electronics industry here by the rapid increase in electronic imports from Japan. Most of the products offered at the New York show would naturally be sold to electronics manufacturers. Apparently the Japanese feel that if they can sell to U. S. electronics manufacturers, they can sell anywhere.

Horiguchi said that the instrumentmakers had no intention of competing with U. S. gear by undercutting the U. S. industry's price structure. He hoped that "American users would be impressed with wellmade, well designed Japanese instruments, some of which offer features not normally found in comparable U. S.-made equipment." He added that if the JEMIMA members found a market in the U. S., then engineers and technicians would be hired and trained here to service the gear.

JEMIMA has hired a U. S. consultant to make a reaction study, will base future efforts on the results of the study. Horiguchi admits that the instrumentmakers "must make a detailed study of American marketing procedures and advertising techniques," adding: "We must impress on the American engineers the fact that Japanese electronic measuring equipment is of truly high quality."

Japanese executives pointed out to ELECTRONICS that Japanese manufacturers will comply with whatever specifications a customer lays down, including military specs. The instrumentmakers are well acquainted with mil specs, since they build equipment for U. S. forces in Japan to these specifications.

Horiguchi opined that the three major instrument producers in the world—the U. S., Japan and the Federal Republic of Germany—all produce equipment of approximately equivalent merit. He feels that the U. S. lead in the field is probably due to the greater investment in R&D by American manufacturers and government.

JEMIMA, like most Japanese trade associations which are interested in the export market, is trying to hold down copying and even to minimize look-alike equipment among its members. "Most Japanese manufacturers," Horiguchi said, "are making particular effort to emphasize the unusual features of their equipment."

Most of the exhibitors at the Japan Trade Center were small and

medium-sized companies without technical-assistance tie-ins with U.S. and European industry.

Among products shown at New York were a self-balancing bridge cyclemeter operating in the power-frequency ranges; transistorized insulation testers and other resistance-measuring devices in the megohm and terohm ranges; multipen oscillographic recorders; wire-resistance strain gages; a wide assortment of pyrometers and temperature-measuring gear, including thermometers of the thermocouple, resistance and thermistor types; panel instruments; watthour meters (the foundation of the electric-measuring instrument industry in Japan); a vibrating-reed electrometer; a millisecond meter for measuring the motion time of relays, and transistor checkers.

Electronic equipment shown at the earlier exhibition in Moscow included tape recorders, circuit testers, a self-recording spectrophotometer, d-c ammeters, tube and transistor testers, oscillators, oscillographic gear, X-ray diffraction equipment and an electroencephalograph.

Contracts worth $20 million were reported to have been signed at the Moscow show, which stressed industrial equipment for the continuous-process industries, textile-industry controls and machinery, and plastic-making equipment. The exhibit attracted more than a million visitors, cost the Japanese $1 million. Soviet purchasing organizations, as usual, proved to be hard bargainers for the equipment on display; but the Japanese exhibitors, faced with the single alternative of shipping it all back to Tokyo, had to take what they could get. Observers got the impression that the experience raised some doubts in their minds as to just how worthwhile increased Soviet trade would be.

Spokesmen for the Japanese companies at Moscow were quoted in the Soviet press as expecting that the exhibition would lead to an increase in Soviet-Japanese trade. Local commentators note that the $20 million in contracts reportedly signed at Sokolniki exactly equals the amount by which Japan's imports from the Soviet Union exceeding Japan's exports to the Soviets last year.

CIRCLE 41 ON READER SERVICE CARD→

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CEC'S NEW 24-120 LEAK DETECTOR... Instantly locates leaks as small as 5×10^{-11} atm/cc/sec of air (4.8×10^{-6} micron cu ft/hr). Provides positive proof of seals in diodes, relays, switches, vacuum tubes – and it's equally accurate in checking giant systems and containers. This advanced instrument combines high sensitivity with low residual fluctuation and noise...delivers fast response and cleanup.

CEC'S SEMI-AUTOMATIC TEST PORT STATION. Just place the part on the port, turn the function switch and spray with helium when the test light goes on. Unit can also automatically evacuate a bell jar for testing helium-filled components. The test port's reliable vacuum-operated valve can be cycled indefinitely without malfunction or leakage.

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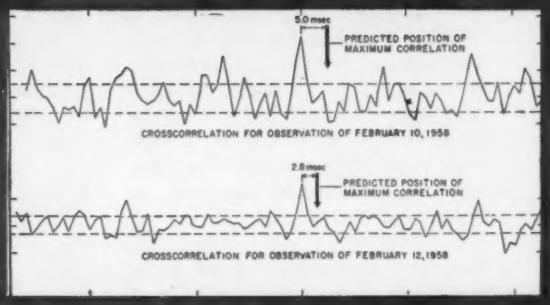
Radar Echoes from Venus . . .

Continental Electronics' giant transmitter at M.I.T. Lincoln Laboratory is the most powerful on earth. With it, man has made his first contact with another planet – by bouncing a radar signal off Venus for a space round trip of 56,000,000 miles.

This is a significant forward step since it means we have pushed our radio signals a hundred times further than ever before. It means we can measure space distances with amazing new accuracy. The powerful pulses from this transmitter were beamed into space from a huge antenna 84 feet from rim to rim. It is the same radar used to sight and track earth satellites and for other space probe programs.

Continental Electronics is proud indeed to be part of this 56 million mile broadcast.

Another Continental Electronics Contribution in Super Power Radio


5.0 msec
PREDICTED POSITION OF MAXIMUM CORRELATION
CROSSCORRELATION FOR OBSERVATION OF FEBRUARY 10, 1958
2.8 msec
PREDICTED POSITION OF MAXIMUM CORRELATION
CROSSCORRELATION FOR OBSERVATION OF FEBRUARY 12, 1958

Correlation curves showing radar returns from Venus. The central peaks indicate the exact time of the radar waves from Earth to Venus and back (about five minutes). Each peak is the result of elaborate calculations by a high-speed digital computer on many thousands of tiny echoes originally beamed by Continental Electronics' transmitter

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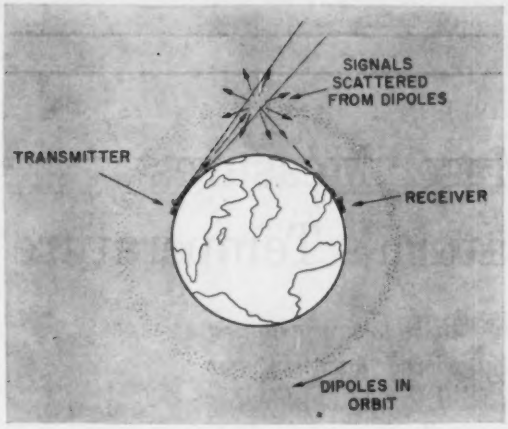
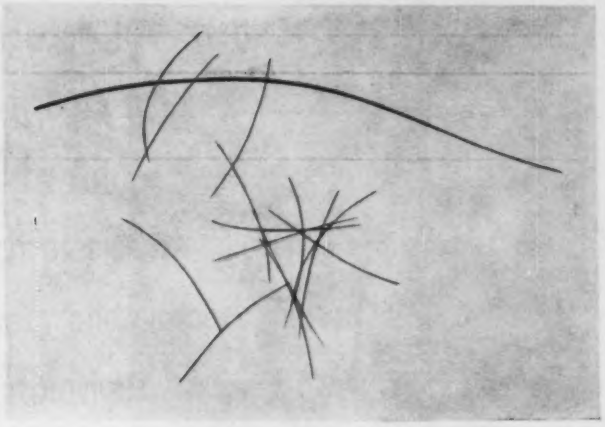




How tuned dipoles will be used for global microwave communications (left). Cat's whisker dwarfs actual metal needles to be sown in orbit (right)

Plan to Orbit Tuned-Dipole Belt

Scientists describe global microwave network for teleprinter, voice and television communications using belt of tiny orbiting needles

TINY, METAL NEEDLES, forming dipoles tuned to 8,000-Mc and placed in orbit as a belt around the earth, may be the key to global microwave communications. So said W. E. Morrow, Jr. of MIT's Lincoln Laboratory as he addressed the International Scientific Radio Union in London earlier this month.

The technique will use reflection from a belt of fibers, each about ½ inch long and ⅓ the diameter of a human hair. A container of fibers will be orbited several thousand miles above the earth. A dispensing mechanism will then release the fibers gradually. In the completed belt individual fibers will be separated by 1,000 feet. Radio waves impinging on the belt will be scattered back to earth to be picked up by receivers. Transmitting and receiving antennas will be trained on the same spot in the belt.

Because the belt will be tuned to a specific frequency, reflected energy will be large compared to that reflected by nonselective surfaces such as balloon-type passive satellites. Use of amplitude-modulated, single-sideband, suppressed-carrier signals should eliminate problems of phase distortion in reflected signals (ELECTRONICS, p 40, Sept. 9).

The technique is an answer to the ever-growing demand for long-distance communications and the desire to use higher radio frequencies where wide bandwidths are still available. At higher frequencies, energy is propagated in straight lines so that the curvature of the earth imposes limitations. Hence, at long distances it is necessary to use reflective or scattering techniques.

Orbital scatter communications uses a reflective principle similar to that used in ionospheric and tropospheric radio communications which have been pursued at Lincoln Laboratory and led to the present concept.

Orbital scatter seems to be useful for teleprinter, voice and television. The electronic and physical characteristics of the dipole belt will afford a large number of exclusive communications circuits. Because the belt would be relatively stationary in space, there will be no need for high-speed tracking equipment to keep transmitting and receiving antennas trained continuously on the belt.

With two belts, one east-west over the equator and the other north-south over the poles, communications could be established between any two points on earth. Because all of the active equipment is placed on the ground, the technique is thought to offer high system reliability.

Belt lifetime can be varied from months to years depending upon the altitude and inclination of the orbit and the design of the dipoles. As the belt lifetime ends, the dipoles are dissipated harmlessly in the atmosphere. Initial experiments planned by Lincoln Laboratory call for belts with short lifetimes.

Theoretical studies show that solar radiation pressure, atmospheric friction, sun and moon gravitation, micrometeorites, magnetic field effects and high-energy particles will not produce undesirable changes in the belt.

Lincoln Laboratory scientists believe that orbiting dipoles will have negligible adverse effects on the use of space and on optical, radio and radar astronomical observations.

Although work on the technique is sponsored jointly by Army, Navy and Air Force, it is thought that orbital scatter communications can serve both civilian and military purposes. Orbital scatter has definite military antijamming advantages.

Later in the London meeting, a resolution was adopted expressing concern that dipoles in orbit may interfere with astronomical radio and optical studies. Steps were urged to prevent such interference.

←CIRCLE 42 ON READER SERVICE CARD

Maser Measures Saturn's Temperature

Low-noise preamplifier may spot unsuspected hazards, cut costs of space exploration

Lloyd Cross (left) and Jerald Cook developed and installed sensitive ruby maser in this 85-ft radio-telescope

RUBY MASER AMPLIFIER developed by graduate students at University of Michigan has made the first positive detection and measurement of radio waves from the planet Saturn.

Such measurements can help reduce the cost of future planetary explorations, in addition to their basic contributions to science, Prof. Fred Haddock, the university's head of radio astronomy, told London's 13th general assembly of the International Scientific Radio Union.

Measuring radio waves emitted from various depths within Saturn's atmosphere, the maser amplifier found the planet's atmospheric temperature is 100 degrees Kelvin (minus 283 degrees F). Accurate within about 10 percent, these temperatures were about those to be expected on the basis of optical studies, according to Haddock.

Jerald Cook and Lloyd Cross of the university's Willow Run Labs worked with Allen Barrett and William Howard, Phd's in the Radio Astronomy lab, to design, build and connect their ruby maser amplifier to the university's new high precision 85-ft radio telescope.

Masers are relatively free from the self-produced static inherent in standard radio receivers, Cook said. Such static can drown out weak incoming signals in conventional radio amplifiers.

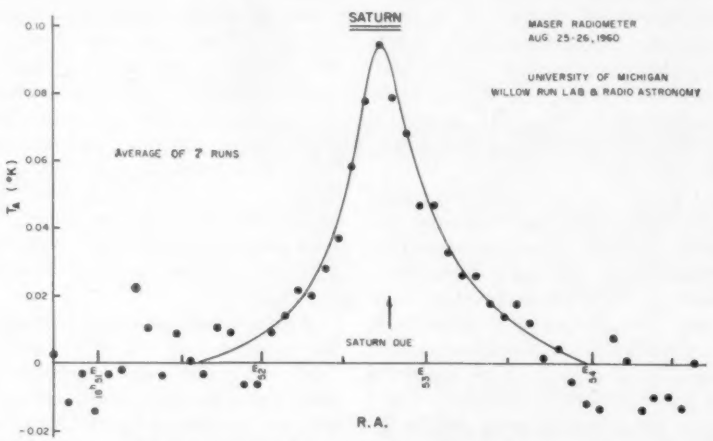
Cook told ELECTRONICS the U of M team hooked its maser to a Dicke radiometer, conventional except that it required no large switching signal.

Cooled to the temperature of liquid helium, the maser boosted strength of the signal coming in from space 20 db before feeding it to a standard superheterodyne whose local oscillator beat the incoming frequency down to an intermediate 30 Mc for further amplification and detection.

Enthusiastic with first results, Cook said, the team is now planning further improvements in the horn antenna to suppress spillover picked up by the highly sensitive maser.

"New technological developments make it appear possible to improve the performance of the maser receiver tenfold, while making its operation very much easier," said George Mahkov, acting head of WRL's solid state physics lab.

Radio astronomical observations of planets, preceding explorations by space probe instrumentation and by man, could save millions of dollars in space exploration planning, Haddock says.



Saturn's signal peaks from background radiation. Curve combines results from seven scans of planet

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1/100% accuracy
1/100% gain stability
1/100% linearity

Sixteen channels of data reduction (Type 492) requires only 8¾" of rack space. Power supply occupies only 5¼". The combination of accuracy, stability, fast response, and size is unmatched.

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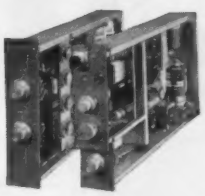
Type 491 and 492
Differential
Data Amplifiers



Type 492 Amplifier (left) provides 2 channels of precision amplification per unit. The Type 491 (right) is a single channel unit, with input coupler for added versatility.

featuring

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1/100% gain stability—for 1,000 hours at normal ambients
1/100% linearity—for full output
All-transistor construction
1/400th second response—to step input
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Infinite rejection—of common d-c signals
120db rejection—at 60 cps
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Versatile input couplers (Type 491)

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Conference Scans Sea and

Instrument users, makers reveal scope of their accomplishments and ambitions this week

THIS WEEK's five-day meeting of the Instrument Society of America, was exceptional in comparison with many industry conferences in that users participated as actively as manufacturers.

The conference was held at the New York Coliseum. User participation was evident from the first day when E. D. Reeves, vice president of Humble Oil and Refining, as well as O. W. Manz, executive vice president of Consolidated Edison Company of New York, formed part of the keynote session.

Reeves spoke on Progress Through Instrumentation in the Petroleum Industry, and Manz spoke on the same subject as applied to the power industry.

Representing the side of the instrument manufacturers were Don Mitchell, president of General Telephone and Electronics and John Johnston, Jr., president of the instrument society.

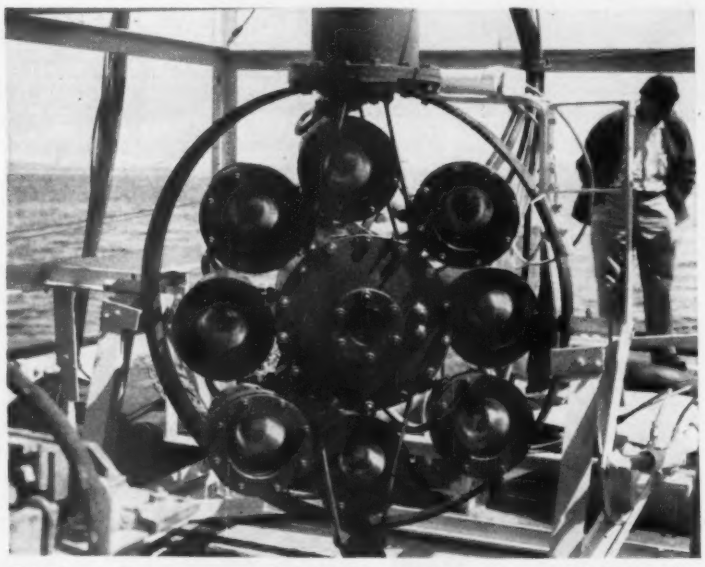
Among others who gave talks at the meetings was Dean J. R. Ragazzini of New York University who told his audience that progress in automatic control is already beginning to have an impact on engineering education.

He said that engineers of the future will have to learn a whole new variety of subjects in addition to their present curriculum of subjects . . . if they wish to keep up with tomorrow's technology.

From Monsanto Chemical Co., T. J. Williams gave a critical evaluation of the present status of process control by digital computers. He also discussed projects in the near future which will have influence on the chemical and petroleum industries.

In the five days of the conference 200 papers were presented to convention goers. Estimates are that some 3,500 persons attended the show with 400 manufacturers dis-

Tv Inspects Damaged Pontoon Bridge



Closed circuit tv camera and eight 500 watt lamps, in watertight housing, check Hood Canal (Washington) bridge's underwater anchors

Space

playing their wares in exhibits said to be valued at well over $2½ million.

This year, perhaps more than ever before, the scope of applications of electronic instruments was shown by the technical sessions that ranged from the stratosphere and beyond, and down to the ocean floors.

In the space sessions, a talk was given by P. B. MacReady of Meteorological Research, Inc., on Automatic Retrieving of Stratospheric Research Equipment. Also speaking was R. T. McCoy of Bendix Corp.'s Instrument division. He gave his audience a series of relative comparisons between rod and bead thermistors for atmospheric temperature surroundings.

From the National Bureau of Standards, a talk by D. M. Gates, had as its subject, spectroscopic observations of the stratosphere and mesosphere.

One highlight of the sessions on underwater instrumentation was a detailed description of the instruments aboard the bathyscaphe *Trieste*, which in the winter of 1959-60 established the world's record for manned deap-sea dives by descending some seven miles to the bottom of the Marianas Trench off the island of Guam. Appearing at the session was Andreas Rechnitzer, scientist in charge of the *Trieste*, and G. Farrell, Jr., one of the men abroad the bathyscaphe when it made the record descent.

Hinting that the future of underwater research will have many parallels to the present state of space research were papers with such titles as:

Design and Engineering of Deep Sea Instrument Encapsulation and Vehicles; Instrumentation for Underwater Ordnance; Oceanographic Requirements vs Instrumentation Capabilities and Underwater Pipeline Engineering.

Capacity audiences attended sessions consisting of reports from the International Federation of Automatic Control Conference.

That conference was held in Moscow earlier last year.

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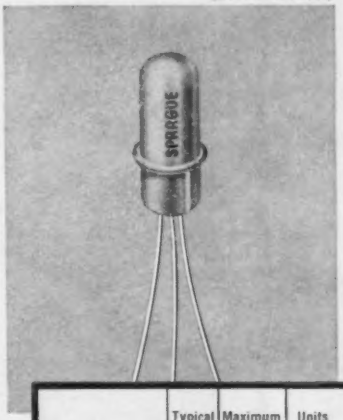
Type 2N501 Super High-Speed Micro-Alloy Diffused-Base Transistors

(2 X Actual Size)



	Typical	Maximum	Units
Rise Time (t_r)	9	18	mμsec
Storage Time (t_s)	9	12	mμsec
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In circuit with current gain of 10 and voltage turn off.

Unexcelled for super high-speed computer applications, Sprague's Type 2N501 Micro-Alloy Transistors combine high gain and high frequency response with unusual stability and high operation efficiency even under severe environmental conditions and life tests.

Sprague's mechanized electrochemical process permits the fabrication of a graded base transistor with no intrinsic base region. The Type 2N501 can thus maintain its super high-speed switching characteristics right down to its saturation voltage, providing all the advantages of direct-coupled circuitry with no impairment of switching speeds.

Write for complete engineering data to Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Mass.

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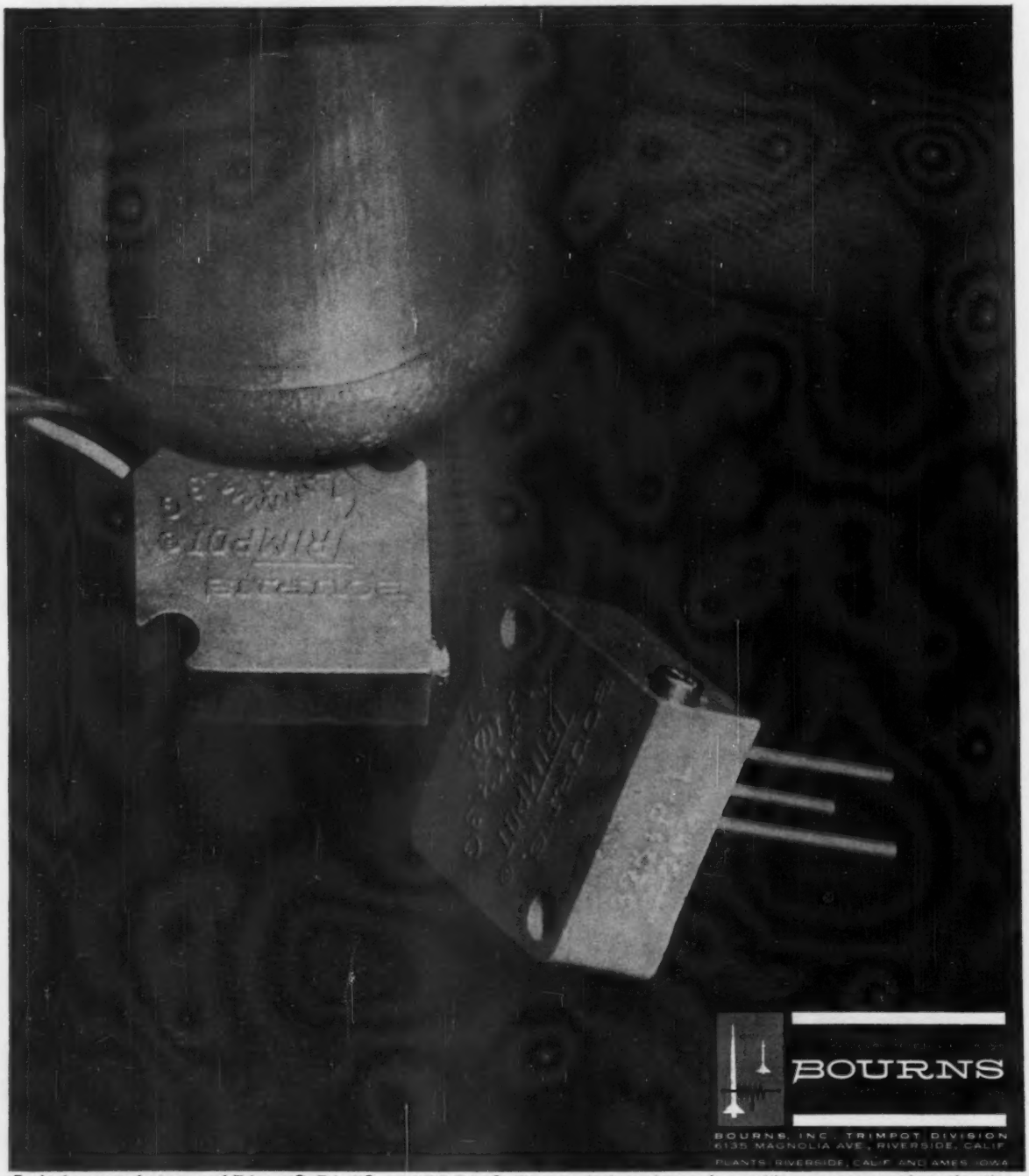

Exclusive manufacturers of Trimpot®, Trimit® and E-Z Trim®. Pioneers in transducers for position, pressure and acceleration.

Language laboratories like this RCA-installed system at Rosemont College, Philadelphia, are pointing the way for new electronic teaching methods

Educational Market Growing Fast

TOTAL U. S. BUDGET of about $20 billion makes education one of our nation's biggest businesses. As a new semester starts this month, electronics manufacturers are viewing this market with increasing interest.

More and more electronic equipment will be used in schools. Growth areas will most likely be systems allowing students to see and hear instructional material. Following closely will be automatic library research systems, electronic record keeping devices and gear that takes burdens from teachers.

Although some educators shy away from classroom automation, a growing number of teachers and school officials accept present technology and help find new uses.

There are now more than 4,000 primary schools in the country wired for teaching foreign languages, literature, music appreciation and speech. In some cases, equipment for these schools was originally designed for armed forces training in World War II.

Audio input material for education is now about evenly divided between tape and disk sources. The major portion of this material is devoted to language study. One example is the Detroit, Mich., school system which now owns some 200 tape recorders used in language laboratories.

One approach to computer learning devices is a system where material to be taught is displayed on a viewing screen beside a panel containing some 40 pushbuttons that permit the student to answer a number of questions.

When the student makes an error, the system automatically reprograms itself, going over the weak subject in further detail until questions are answered satisfactorily. Presentation may be as text, illustrations or motion pictures.

A system with hopes for academic application is a computer built originally for use in medical schools. In medical training, students create inputs in pushbutton form equivalent to their diagnoses of human tissues. The computer processes their information, compares it with a standard, and informs the instructor of areas in which further study is needed. Changed programming makes the system suitable for other subjects.

A television tape system reportedly in development will be able to record a reel of tape and play it back on classroom tv receivers. Spokesmen predict that prerecorded television tapes will be circulated in much the same way that educational films are.

In a recent survey conducted at some 300 colleges, estimated costs for courses taught by television came to $2.80 a pupil class hour, as compared to $12 to $18 for conventional instruction. One school specializing in music and art reported a drop from $16.75 to $1.71 a pupil class hour by using a combination of electronic teaching systems.

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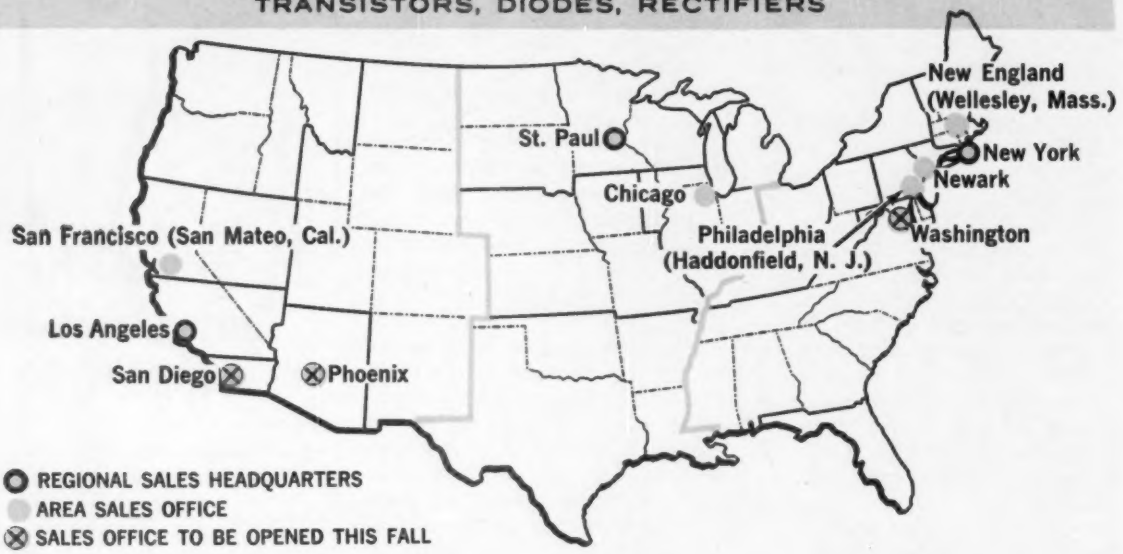

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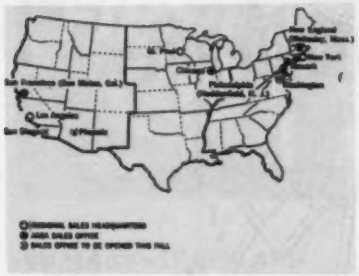

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CIRCLE 200 ON READER SERVICE CARD

MEETINGS AHEAD

Oct. 3-5: Nuclear Science, Annual, PGNS of IRE, Gatlinburg, Tenn.

Oct. 3-5: Communications Symposium, PGGS of IRE, Hotel Utica & Utica Memorial Auditorium, Utica, N. Y.

Oct. 4-6: Radio Interference Reduction, PGRFI of IRE, Armour Research Foundation, Chicago.

Oct. 4-7: Instrumentation Symposium, Nat. Inst. of Health, Bethesda, Md.

Oct. 4-9: Data Processing Systems, Large Volume, Fall Meeting, AIEE, New York City.

Oct. 5-6: Value Engineering, EIA, Disneyland Hotel, Anaheim, Calif.

Oct. 10-12: National Electronics Conf., Hotel Sherman, Chicago.

Oct. 11-14: Audio Engineering Soc., Annual Convention, Hotel New Yorker, New York City.

Oct. 13-14: Engineering Writing & Speech, Annual Symposium, PGEWS of IRE, Bismark Hotel, Chicago.

Oct. 14: Engineering for Reliability Conference, PGRQC of IRE, Cooper Union, New York City.

Oct. 14-15: Quality Control Conf., ASQC, Broadview Hotel, Wichita, Kan.

Oct. 17-19: Adaptive Control Systems Symposium, IRE, Garden City Hotel, Garden City, N. Y.

Oct. 18-20: Battery Symposium, Ministry of Aviation, S.R.D.E., The Pavilion, Bournemouth, England.

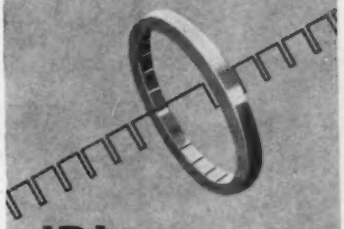
Oct. 19-21: Space Navigation, PGSET of IRE, Deshly-Hilton Hotel, Columbus, O.

Oct. 19-26: International Congress & Exhibition for Instrumentation & Automation, INTERKAMA, Dusseldorf, Germany.

Oct. 24-26: Aero & Nav. Elec. Conf., PGANE of IRE, Lord Baltimore Hotel, Baltimore, Md.

Oct. 26-27: Computer Applications Symposium, Armour Research Foundation & Illinois Inst. of Tech., Morrison Hotel, Chicago.

Time-Sharing Problem?



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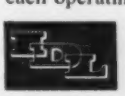
For example, Switch No. 500660 is a complete unit within a compact case, available at reasonable cost and capable of sampling up to 180 transducers. It combines 2 poles of 30 data channels with 2 poles of 60 data channels, each operating at 5 rps.



For further information, write for Technical Bulletin No. 500660; or let us propose a solution to your Time-Sharing Problem.

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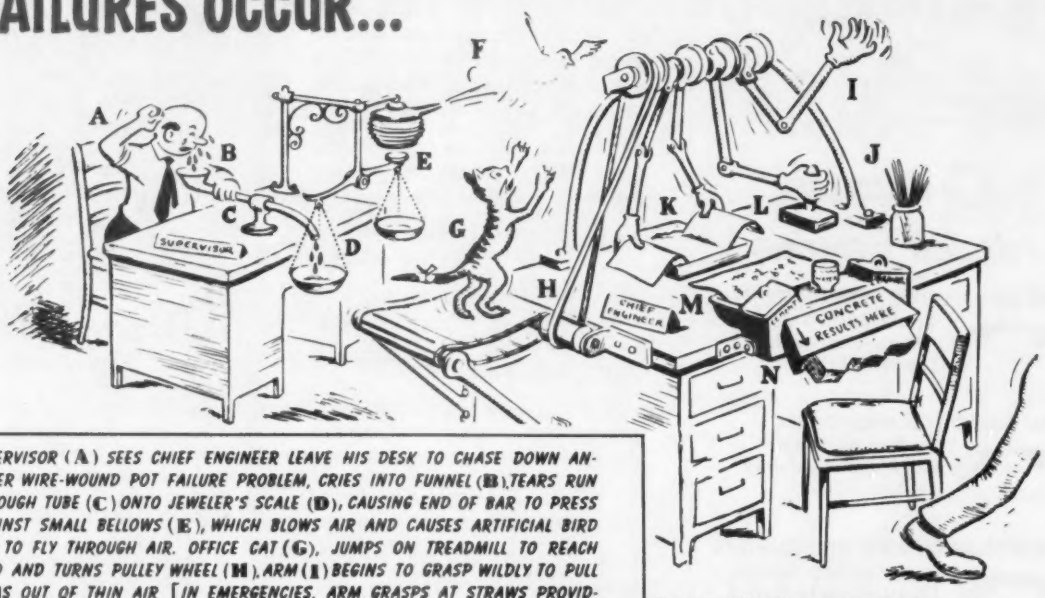
CIRCLE 51 ON READER SERVICE CARD

HERE'S ONE WAY TO GET WORK DONE WHEN WIRE-WOUND POT FAILURES OCCUR...



SUPERVISOR (A) SEES CHIEF ENGINEER LEAVE HIS DESK TO CHASE DOWN ANOTHER WIRE-WOUND POT FAILURE PROBLEM, CRIES INTO FUNNEL (B), TEARS RUN THROUGH TUBE (C) ONTO JEWELER'S SCALE (D), CAUSING END OF BAR TO PRESS AGAINST SMALL BELLOWS (E), WHICH BLOWS AIR AND CAUSES ARTIFICIAL BIRD (F) TO FLY THROUGH AIR. OFFICE CAT (G), JUMPS ON TREADMILL TO REACH BIRD AND TURNS PULLEY WHEEL (H), ARM (I) BEGINS TO GRASP WILDLY TO PULL IDEAS OUT OF THIN AIR [IN EMERGENCIES, ARM GRASPS AT STRAWS PROVIDED (J)]. ORIGINAL IDEAS DEVELOP FURTHER IN TRAY (K), DESIGN RECEIVES SUPERVISOR'S APPROVAL STAMP (L), PASSES INTO HOPPER (M), MIXES WITH CEMENT, WATER AND GRAVEL, AND EMERGES IN CONCRETE FORM (N). NOTE: MACHINE REACHES EFFICIENCY OF 87.326% IF OFFICE CAT IS KEPT HUNGRY.

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PRIMARY-STANDARD
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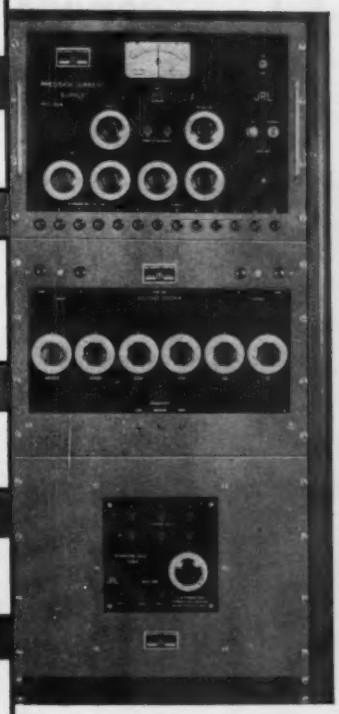
VOLTAGE 0.0015 % ABS.
CURRENT 0.003 % ABS.

ULTRA-PRECISE
DC VOLTAGE GENERATOR-CALIBRATOR
0.0015 % ABSOLUTE

ULTRA-PRECISE
DC CURRENT GENERATOR-CALIBRATOR
0.003 % ABSOLUTE

ULTRA-SENSITIVE
DC AMPLIFIER-NULL DETECTOR
2μV THRESHOLD



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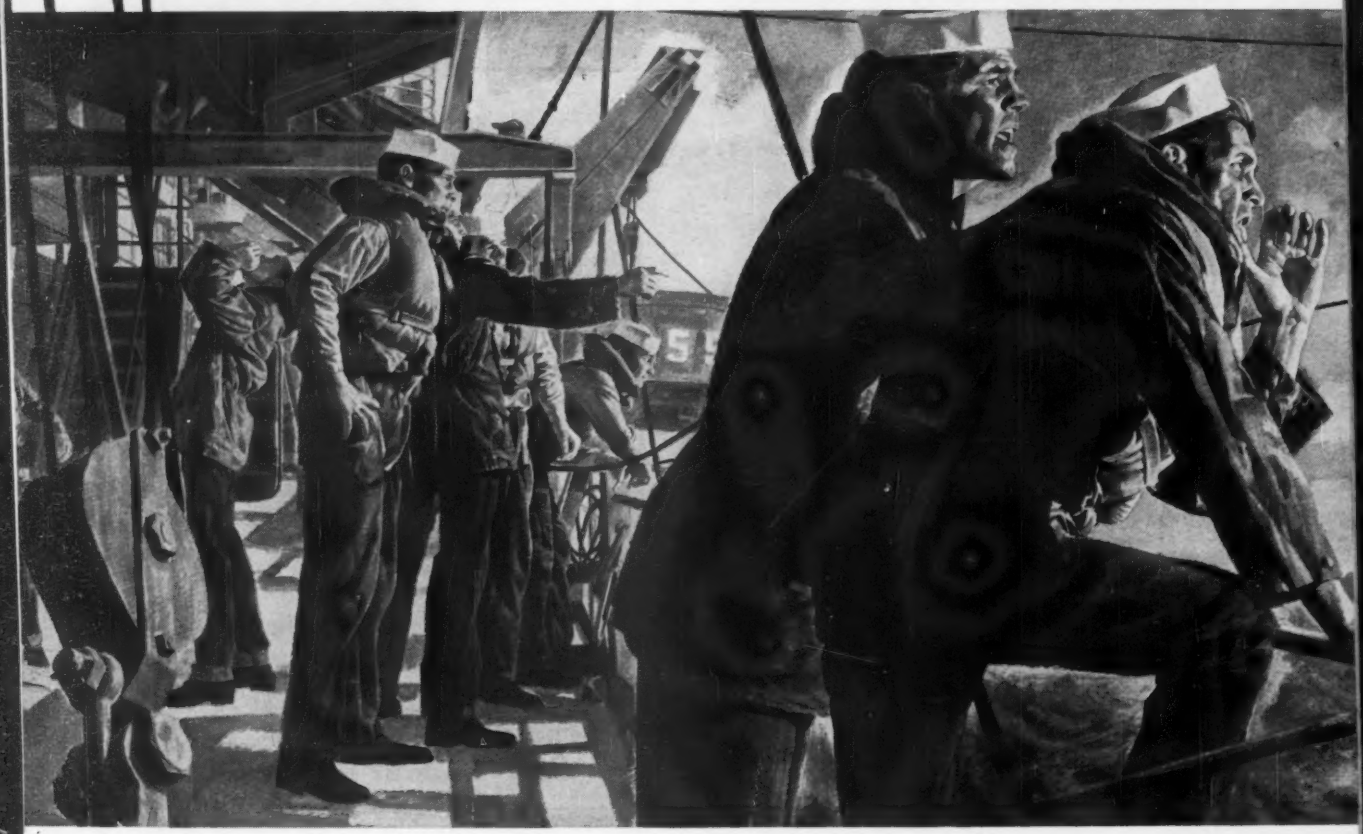
RUSHING TO A RADAR'S RESCUE

Lockheed Electronics engineers – anywhere –service every make of electronic equipment



A ship's "eyesight" needs immediate attention–a Lockheed Electronics service engineer swings aboard on a breeches buoy to make on-the-spot adjustments that keep critical electronic systems at peak performance.

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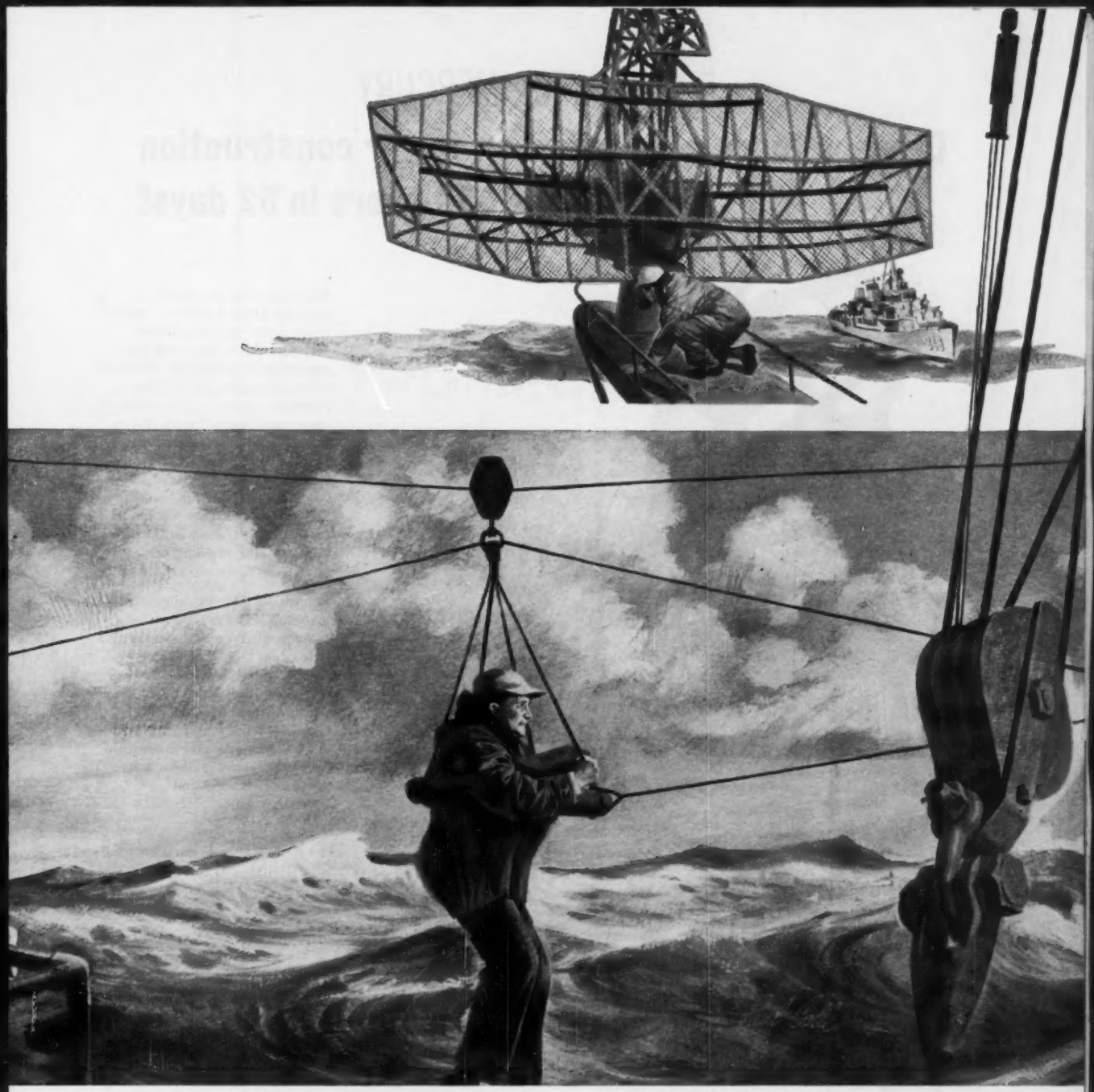

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CIRCLE 55 ON READER SERVICE CARD

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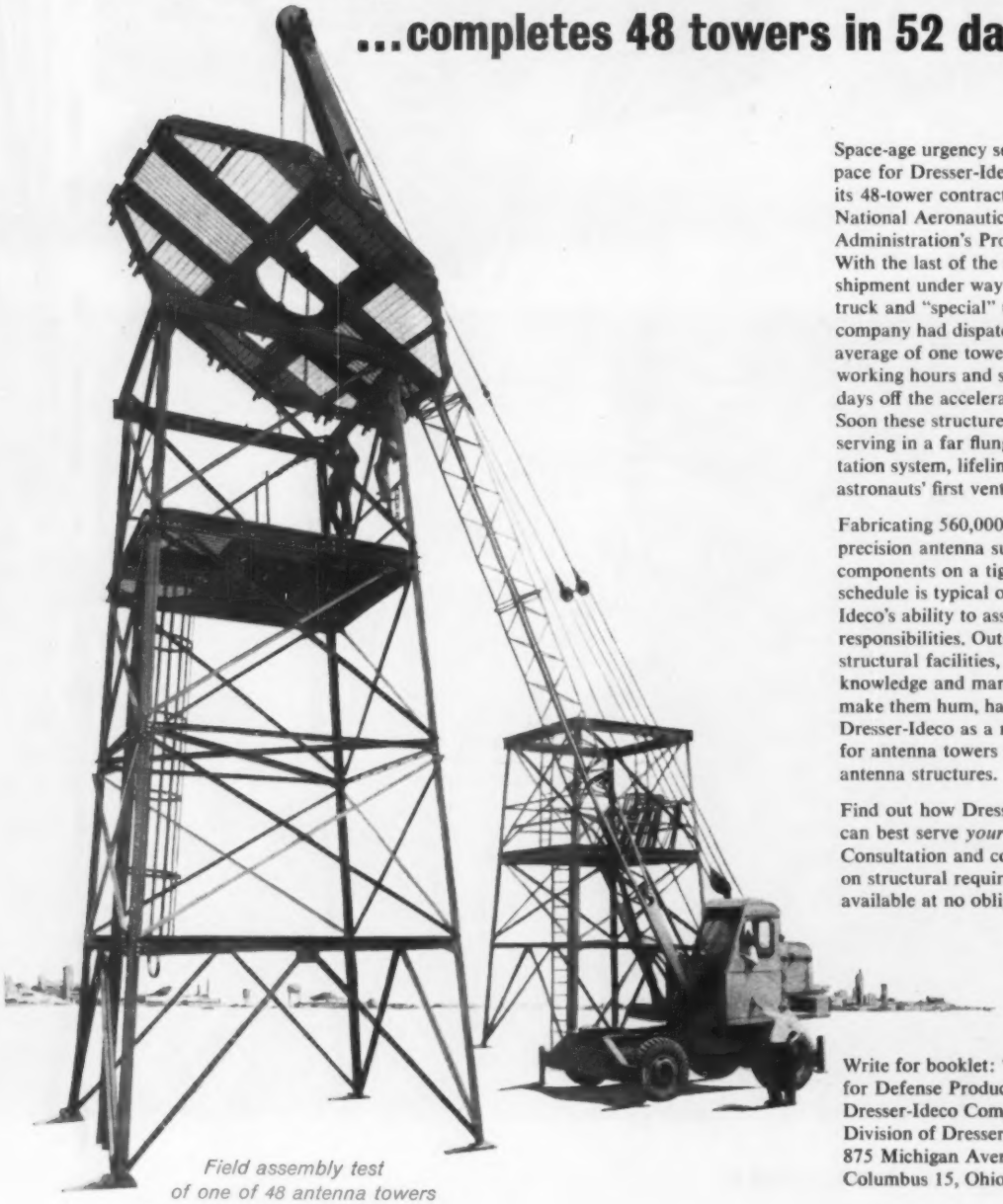
Dresser-Ideco puts wings on tower construction ...completes 48 towers in 52 days!



Field assembly test of one of 48 antenna towers for the Man-In-Orbit program. This Dresser-Ideco contract included transmitting, receiving and boresight designs.

Space-age urgency set the pace for Dresser-Ideco in fulfilling its 48-tower contract for the National Aeronautics and Space Administration's Project Mercury. With the last of the complete shipment under way via exclusive truck and "special" train, the company had dispatched an average of one tower every nine working hours and shaved 12 days off the accelerated schedule! Soon these structures will be serving in a far flung instrumentation system, lifelining our astronauts' first venture into space.

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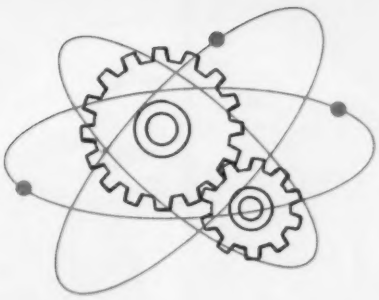
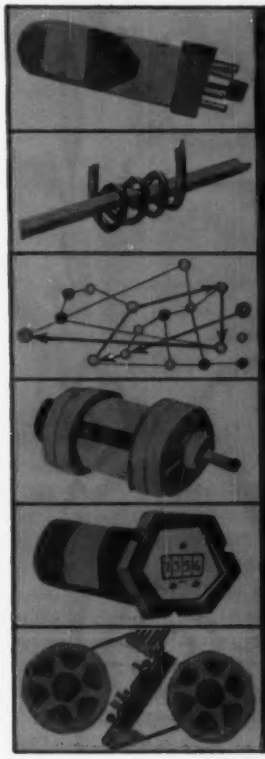


ELECTROMECHANICAL DEVICES AND SYSTEMS FOR ELECTRONICS

By MICHAEL F. TOMAINO and GEORGE J. FLYNN, Associate Editors



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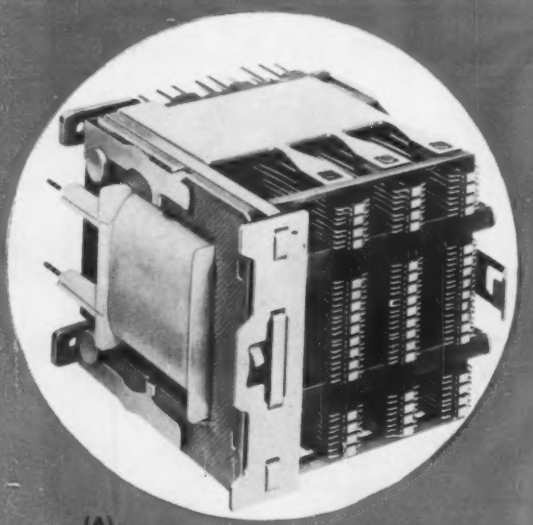
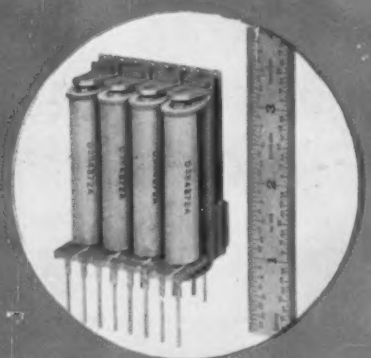


(A)



(B)

FIG. 1—Automatic Electric's new wire-spring relay (A) transfers up to 51 circuits quickly for 100 million or more operations without readjustment. The company has a space-saving relay with a common keel piece and a common fixed contact assembly (B), which is used in data processing equipment

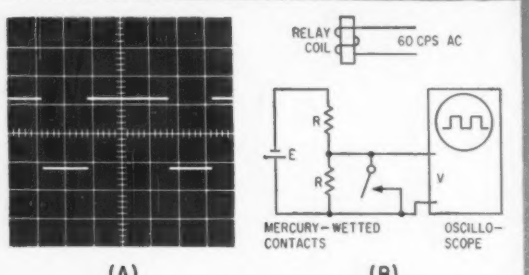


FIG. 2—Oscilloscope trace (A) of the contacts of a Clare chopper relay switching a battery in circuit (B) shows freedom from bounce, characteristic of mercury-wetted relays

RELAYS AND

The relay is available in almost infinite

on how the relay performs as an integral

WHEN PROPERLY CHOSEN, contact relays are among the simplest, most desirable, and mose useful components in electronic switching circuits.

The relay, selector, crossbar, chopper, all simple devices, meet almost any life requirements, are available from a wide range of voltages, currents, frequencies or temperatures, unaffected by temperature changes[1-4].

These devices can handle many circuits and control many sources. Off-on action is positive, construction is flexible, and the devices are readily available. Multiple contacts can be arranged with a single control, characteristics are measurable, and the predicted reliability can be calculated with accuracy.

The contact principle, used to open and close the circuit, is useful where definite on-off, low-noise current control is required.

And yet the relay has been among the least understood, least standardized, least controlled by specification, and the most abused of all component parts employed in electronic equipment today[5].

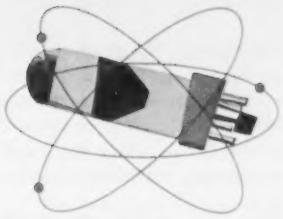
THE CONTACT RELAY—If the relay is little-understood and most abused, insufficient knowledge of what it can do and how to apply the device may be one cause. If least standardized and least controlled, perhaps a clearer definition of relay specifications, design capabilities and circuit requirements are in order. For the contact relay, with its simple parts, is available in almost infinite arrangements to perform many circuit functions: simple current control, time delay, sequencing, circuit selection, stepping, holding for manual reset, interlocking; and combination of these functions.

Contact devices can now switch loads from dry-circuit to rated loads with high reliability if care is used in selecting the device. Disadvantages such as contact bounce, mass limitations, coil transients, failure of contact material and moving parts need no longer apply.

Complete information on the hundreds of electromechanical relays of all types, manufactured in the United States, is now available[6]. But when this information does not indicate the proper choice, a relay specialist can determine the devices or circuit combinations that will perform the function required.

A wire spring relay, and a unit now used in data processing are shown in Fig. 1A and B.

MERCURY-WETTED CONTACTS—The type (Fig. 2) provides reliability for equipment that uses large



RELATED DEVICES

arrangements to perform many circuit functions. Final choice should be based part of the circuit. Each design should be evaluated individually

numbers of relays. Advantages are high operating speed and consistency of contact resistance and timing. Freedom from contact bounce makes them useful in automatic equipment, computing systems, tabulating machines, sorters, totalizers, signaling devices and data processing equipment. New developments in mercury-wetted relays have increased the applications for which they can be used.

One small mercury-wetted relay is about $\frac{3}{16}$ inch in diameter and about one inch long[7]. This unit, a non-position sensitive device, is planned for computers and where reliability over millions of operations is required. The device will be on the market early next year.

A small mercury switch, now available, has had initial application as a reverse switch for a portable electric motor clutch[8]. Suggested applications for this switch are in hearing aids and paging devices.

CONTACT METER-RELAYS—These devices are finding applications in electronics because they can stabilize and simplify circuits. A control system built around meter relays was described last year (ELECTRONICS, Mar 6, 1959, p 41) and also an instrument system (ELECTRONICS, Aug. 7, 1959, p 134).

The meter relay is an amplifying device that can be actuated by a signal as small as one-fifth amp. It is also a sensitive coil D'Arsonval meter, continuously indicating a signal from any variable that can be measured electrically through a transducer. A meter relay is also a monitoring device with easily adjustable signal-set points, by which control action can be triggered. A meter relay can be used as an amplifier with a power gain of 1×10^6.

A potentially broad field of application for meter relays is in vacuum-tube voltmeters. A meter relay can be inserted in such a circuit in place of a conventional meter. The circuit then has built-in control or alarm features along with its ability (because of its high input impedance) to measure voltage without loading the circuit. Automatic ground-testing of missiles is one application for vtvm circuits that include meter relays.

One meter relay manufacturer recently described a meter relay voltage monitoring circuit for the ground-support system of the Titan ICBM. The relay eliminated vacuum tubes[9]. Alternative circuits would have cost eight to ten times more.

RESONANT REED RELAY—This is a frequency-selective, high-Q device that can be used in a variety of ways. Miniaturized resonant reed relays are available in the a-f range from about 100 to 1,000 cps, with a bandwidth of one percent and a sensitivity of one milliwatt. Primary developments are the twin reed, anti-vibration and shock designs for military use; zero coupling to the base; narrow-band drop-out frequency curves; high sensitivity and small size.

There is wide potential application for these devices: command signaling, point-to-point communication, security coding, telemetry, doppler frequency analyzers, underwater transmission and signal analysis and process control.

One series of resonant relays is now being included in complex systems since the resonant reed relay combines several circuit functions that tie in with information theory[10]. The primary advantages of these units, are zero mechanical coupling from the reed to the base, making it mountable on nearly any electrical chassis; its dual-reed structure making it nonresponsive to external vibration and shock; and a compliant contact that allows the pull-in and drop-out frequency response curves to be almost identical. New developments will probably extend range and output handling capacity. Extended use: mobile equipment[11].

Instruments with tuned steel reeds for indicating frequency of a-c by resonance, once imported from Europe, are now made here. These resonant-reed relays and oscillator circuits are used in equipment for signaling, remote operation and supervisory control.[12]

THERMAL RELAYS—These units respond to the heating effect, rather than the electromagnetic effect of energizing current. Each has an expanding element heated by the energizing current, and produces a time delay between the moments of energization and contact actuation.

A high precision thermal relay, can take 11 msec of 50-g shock and 2,000 cps, 20-g vibration without adverse effect. Unidirectional acceleration produces only a fraction of the effect found in earlier thermal relays[13].

POWER AND LOW-POWER COMBINATIONS—Frequently it is desirable to select a single electromechanically operated device that will handle both high power (up to 10 amp, 600 v) and low power (a few milliamps at low voltages). This combination is found in electronic switching, grid control and instrument controls

where high electrical and mechanical reliability are important.

A typical solenoid relay performing these functions is available[14]. These relays can be equipped with both double-break silver contacts for power circuits, and multibreak palladium contacts for low-power use.

PREAMPLIFIER CIRCUITS—These are built within hermetically-sealed relay housings and can boost the energizing signal or provide impedance match. The only external circuit component is an impedance-matching resistor. Various configurations of this development are now in prototype stages[15].

Positive relay action can be obtained from a miniature relay with a signal as low as 0.6 mv. The transistor amplifier boosts signal strength to the required level with minimum power requirement and without lowering the relay's environmental rating.

Resilient bifurcated construction is featured in a line of high-level switching relays[16]. And a pill-box relay, made specially for printed circuits or space-saving applications lies flat against the board, projecting less than 0.42 inch from the surface[17].

CROSSBAR SWITCH—This is essentially a multiple relay. The devices simplify switching and monitoring design and are finding use as control components in logic systems. For signal switching, crossbars handle up to 2,500-v a-c down to microvolts d-c. Frequency extends from zero to 70 Mc and leakage resistance between switching elements runs as high as one million megohms.

A crossbar is a three-dimensional arrangement of electrical contacts that can be individually operated by a coordinate actuator system. The crossbar can handle many circuits in a compact package and provides direct logic in digital circuits.

One familiar crossbar provides a matrix of 1,200 switching points and is rated at 20 million operations a crosspoint at 100 ma, noninductive at 50 v d-c[18]. Present rating of 5 watts drives many outputs directly. Contact bounce is less than 200 μsec on make, with no bounce on break. Gold contacts develop between 30 and 35 grams of contact pressure. Shielding gives the switch characteristics of a 75-ohm coaxial cable. About 15-20 millisec are required to operate the hold actuator, but this can be cut in half by operating from a high-impedance.

The crossbar switch of another manufacturer is used for storage, programming and scanning. These switches are applied to analog and digital computer functions as a memory for programming and sequencing, high-traffic communications, automatic programming, cable and circuit testing[19].

Use of solid-state circuits in crossbar switches has raised the demand for a crossbar with short connecting time. To meet this, a wire crossbar was designed in Japan[20].

An American manufacturer of crossbars lists some factors to consider when the crossbar should be used[21]. If the number of positions to be scanned are below 40 or 50 six-wire channels, a stepping switch or relay matrix is a more logical choice. Scan speeds, modes of control, signal characteristics, operating life and reliability, and how the contacts should operate are important.

CONTACT MODULATOR—The chopper is a contact-making device for modulating, demodulating and switching d-c or low-frequency a-c information. Development of high-temperature choppers, precision units and small, rugged types for printed circuits is underway.

Literature of the chopper art is extensive, and manufacturers have supplied information on choppers in microvolt switching systems[22].

CONTACT MATERIALS AND THEIR CHARACTERISTICS

Many electromechanical failures are traced directly to contacts. The contacts themselves should be the initial parameter investigated. Materials should be chosen on the basis of component design, conductivity requirements, tendency for surface contamination, wear, oxidation resistance, contact pressure, currents and voltages. Many papers have been written on contacts (see below) and the design engineer should carefully evaluate all materials on the basis of each requirement. (See C. B. Gwyn ref.)

Silver and its alloys	Widely used electrical contact materials. Pure silver has the highest electrical and thermal conductivity of any contact material
Noble metals	
Gold[a]	Substantial resistance to oxidation, corrosion, atmospheres and humidity. Noble metals are more widely used as alloys, for economy and for enhanced performance, particularly for low current, low pressure, low voltage applications where high ambient temperatures, high humidities and corrosive atmospheres are prevalent
Platinum	
Palladium[b]	
Osmium	
Rhodium	
Iridium	
Ruthenium	
and their alloys	
Refractory Metals	High melting points, tungsten being the highest. All except carbon withstand both electrical and mechanical wear. Combined by powder metal and/or infiltration techniques with silver and copper for high arc erosion resistance, mechanical wear, and increased conductivity, or for dimensional assembly
Tungsten	
Molybdenum[c]	
Rhenium	
Nickel	
Carbon	
Copper and its alloys	Pure copper is not an ideal contact material. Copper plus silver or cadmium is a must for certain fields. Manufacturers of 12-v d-c circuit breakers find that a positive contact segment of 1 percent Cd, 99 percent C, against 50 percent W, 50 percent Ag (Gibson W-10) negative, gives antiwelding properties with a low overall resistance drop. This combination also works well on many 120-v a-c inductive loads in the 5-15 amp range

Alloys secure desirable physical and electrical properties, enhanced corrosion resistance to ameliorate arc induced wear or transfer

Sintered (usually powdered metal-refractory plus high conductivity) materials overcome high inrush current welding, lower rates of electrical and mechanical wear

Combinations (dissimilar) metals and materials in mating contacts produce a synergitic effect, whereby each material increases the effectiveness of the other to a combined value not obtainable when they are used singly

a – Gold and some gold alloys, such as the 69% gold, 25% silver and 6% platinum developed by Bell Laboratories are about the best materials for low low-level circuits

b – Palladium is not a good choice in hermetically sealed enclosures due to affinity for hydrocarbons. Flash platings of gold over some less expensive metal are frequently unsatisfactory due to the tendency of the base metal to migrate through the gold or the gold to wear off after a limited number of operations

Palladium is preferred to silver-cadmium oxide as a contact material for relays which are to be in frequent operation because relays with palladium contact seldom fail when subjected to the prescribed overload or life relay tests whereas relays with the alloy contacts fail unless the gap is widened to 20 mil for the case of normally open contact circuits, and the maximum current load is reduced in the case of normally closed circuits

Palladium is coming increasingly into use for plating pointed circuits, particularly for plug applications

c – Molybdenum and its alloys made by different methods and protected with various coatings is being investigated by Westinghouse as a conductive spring contact material suitable for 3,000 hours operation at 500 C

The following papers on contacts have been given at past Relay Conferences: L. W. Hill, Relay Contact Protection for D-C Application, IBM Corp., 1958; J. W. Scannell, Contact Resistance As It Affects Dry Circuit Relays, C. P. Clare & Co., 1958; A. Schnipper, An Improved Method of Measuring Contact Resistance, Picatinny Arsenal, 1958; H. P. Lynch, An Effort to Promote the Selection of Reliable Contact Systems, General Electric Co., 1959; R. C. Sadler, T. B. Thompson, An Investigation of Relay Contact Resistance by Means of Voltage Current Characteristics, Sandia Corp., Oklahoma State Univ., 1959; C. B. Gwyn, Jr., Let's Take the Mystery Elements Out of Electrical Contacts, Gibson Electric Co., 1960; J. R. Laskie, Use of Activated Carbon in Sealed Relays, National Carbon Co., 1960; P. Mahler, Effects of Contamination in Relay Performance, Picatinny Arsenal, 1960; L. D. DeLalio, C. P. Nunn, Inductive Loading of Contacts, Filtors, Inc., 1960; E. Freudiger, Surface Chemistry of Electrical Contacts, Metals and Controls Corp., Div. of Texas Instruments, Inc., 1960; H. Robertshaw, Single Contact Observations in the Low Level Area, Union Switch & Signal, 1960.

Stanford Research Institute has conducted a study of the contamination problem under Signal Corp Contract DA36-039 SC74965, Feb, 1960

Upper temperature problems and isolation of the a-c input drive from the sensitive microvolt d-c output circuit are capable of engineering improvement by electromechanical choppers. One chopper manufacturer publishes noise specifications of less than one microvolt into 100,000 ohms. And the matching over a period of time is not a problem with the mechanical chopper[23].

The output null has been tabulated for various types of modulators[24]. The present state of the art for transistorized modulators has reached 25 mv output null for transistors; one microvolt output null for mechanical choppers; 50 mv for magnetic (2nd harmonic); 100 mv for magnetic (fundamental); 1,000 mv for the diode modulator; and 10,000 mv for the tube modulator.

A recent modified chopper converts 12-v d-c to 94 cycles, square wave to drive a chopper at a 94-cycle rate. The circuit and component specifications are available[25].

A contact-making modulator is unique, in that its conducting phase approaches perfect conduction and its nonconducting phase represents a reasonable approximation to an infinitely high resistance.

CONTROL DEVICES—Many electromechanical devices are necessary because they are translators—a mechanical force is translated into an electrical force and conversely.

A manufacturer of electromechanical selective control feels these devices are advantageous in interrogation systems, information relay systems, and traffic signaling by code selection[26]. Applications and ideas for coded switch systems have been examined,[27] and there are many opportunities for ingenuity and imagination in this field. Small switching units are now compatible with other reduced circuit components in size. Speed is probably the main limitation to some of these electromechanical selectors.

A new currency counter uses dial-code switching system and automatically counts five hundred notes in any condition. Press a button and the bills will be counted off into hundreds, the machine stopping automatically at each 100. Alternately, by throwing a switch the machine may be used to issue any desired number from 1 to 99. The machine is used for making up payrolls. If two notes are stuck together or a single note is cellotaped, the offending notes are diverted from the main stream without being counted. This device was developed by T. De La Rue of London, is handled by Scan-Am.

A great deal of work has been done by individual companies on specialized switching systems; packages that include sensing voltage differential, current sensing, voltage and frequency sensing, and extremely low power operation in the microwatt level[28].

SUMMARY—C. D. Geer, President of G-V Controls states[29]: "Electronic equipment of a great many types must inevitably rely on electromechanical components, particularly in input and output devices. The most complex and most sophisticated and elaborate electronic equipment, in many instances must receive its input in mechanical terms and ultimately must accomplish a mechanical action, and it is never going to be more reliable than the components which perform these functions. "We believe," says Geer "that this increasing ability of the designer of the electromechanical device to understand the needs of the electronic designer is important to both, for theirs is an essential partnership".

"Beyond this, there are certain intermediate functions for which the designer may choose between an electronic and an electromechanical means of accomplishment. The electronic engineer, faced with this choice, often tends to choose the electronic methods with which he is familiar, but this is not always the best choice. The absence of mechanical parts or of moving contacts is felt to increase reliability, but if, in order to perform the function electronically, an assembly of fifteen or twenty electronic components with fifty soldered joints is needed, the well known mathematics of reliability may indicate an overall reliability inferior to that of a simpler, well designed and well engineered electromechanical component."

R. B. Liepold, Vice-President of Automatic Electric writes: "We have found a very happy marriage between solid-state and electromechanical devices in switching apparatus and industrial control circuitry and continually try to apply these components on the basis of their best application from an economic and engineering standpoint."[30]

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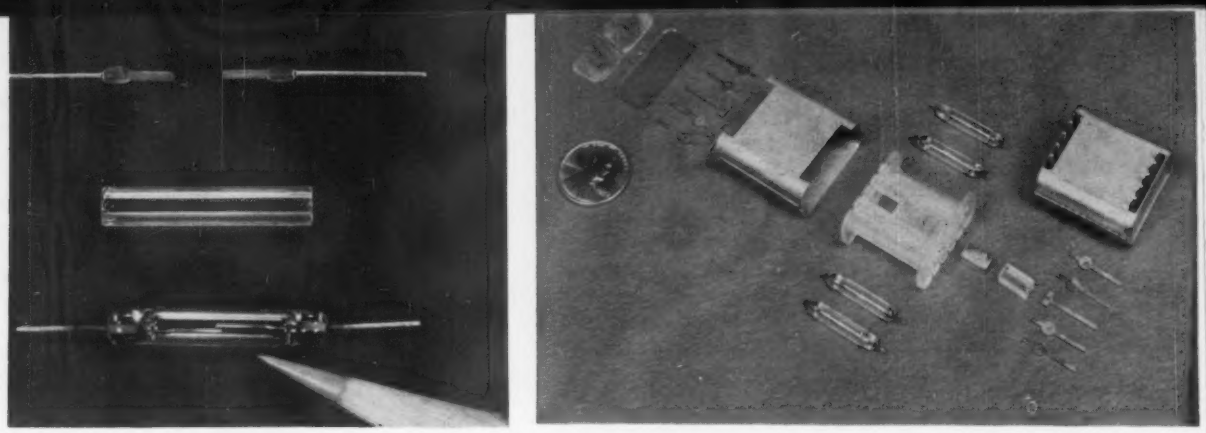


FIG. 1—The G-29 dry-reed capsule, left, can be incorporated into a wide variety of relay combinations. An example is shown at the right. This design, described by O. M. Hovgaard of Bell Labs, and W. J. Fontana of the U.S. Army Signal Research and Development Laboratory, comprises a double-pole-double-throw reed relay that uses four capsules[4]

CONTACT CAPSULES FOR

A variety of simple and complex devices can be built up from basic elements.

Some, like the Ferreed family, attain contact control in micro-second time

ONE BASIC COMPONENT that is simplifying answers to complex problems in using contact switching devices is a glass-enclosed reed capsule[1, 2]. This unit will be exploited as a building block for a variety of devices.

Glass capsule designs have been developed for both the dry-reed switches and the mercury-wetted types. Glass-sealed contacts are important candidates for increased reliability because of their freedom from external atmospheric conditions. These capsules lend themselves to designs in all types of control circuits; Figs. 1, 2 and 3.

There are an increasing number of manufacturers who now have Western Electric Co. licenses to make these devices[3].

Since switches are of major importance to telephone systems, years of attention to the 224A contact capsule have proven it out for economy reliability.

Metallic contacts are useful where definite on-off, low-noise switching is required. These devices will find widespread use not only as telephone switching elements, but in data-transmission systems, multipole transfer for relay structures, coaxial switches and relays, manually operated multipole switches, computers, telemetering equipment, limit or proximity switches, magnetic field indicators, crossbar matrices and multiple slide switches.

The contact capsule uses a pair of magnetic overlapping cantilever reeds, sealed within a tube filled with inert gas. These units are put together in an electrostatically purified atmosphere, to assure complete absence of contamination from airborne dust particles.

Only a coil is needed to provide a magnetomotive force that will pull the reeds together and establish a component that obviates mechanical wear, sticking and binding. And a variety of relays and related switching devices for unilateral control of signals can be built around this module in much the same way as an electronic circuit is built around a vacuum tube. (Fig. 3).

Specifications of dry reeds now available include contact resistance of 25 to 40 milliohms; life expectancy at ½ amp, 28-v d-c; 20 million operations. At ¼ amp, 28-v d-c: over 100 million operations. They can take 40-g shock without false operation; and minimum vibration of 0.08 in. or 20-g (whichever is less).

Continuing tests indicate long life. One manufacturer has had twelve switches operating at 0.1 amp, 120-v a-c resistive load that have made 150 million contacts and are still going strong.

AUTOMATIC ASSEMBLY—A relay manufacturer now has automatic machines that will turn out these capsules at the rate of 2,160 per hour[4]. Both mercury-wetted and dry-reed types are produced.

The U. S. Army Signal Research and Development Laboratory has sponsored a program for development of a miniature version of the 224A capsule. This small version, the BTL G-29, is a ⅛-in. glass tube, ¾-in. long that encapsulates two nickel-iron alloy reeds[5, 6].

Relay manufacturers are making headway towards mass-production techniques for the small capsule. The job is more than one of scaling down production methods for automatic assembly of the 224A reed. Holding and positioning reeds and capsule, heat-sealing and filling the pill-size glass tube with inert gas in limited space, raise production difficulties. However, the G-29 seems to be adaptable to automatic and semiautomatic production methods[7].

The G-29 shows a mechanical life of 30 million cycles minimum, 30-g minimum shock resistance, and ability to take up to 2,000 cps vibration at 10 g. Electrical characteristics include an operating sensitivity of 9 mw, contact capacity of 0.125 amp at 28-v d-c resistive, and an

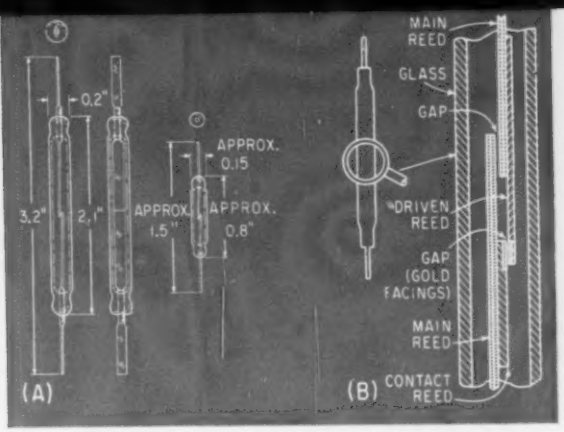


FIG. 2—Magnetic reed capsules in production (A). Modified version of contacts, such as the Struthers-Dunn reed (B) are planned to improve circuit stability[9]

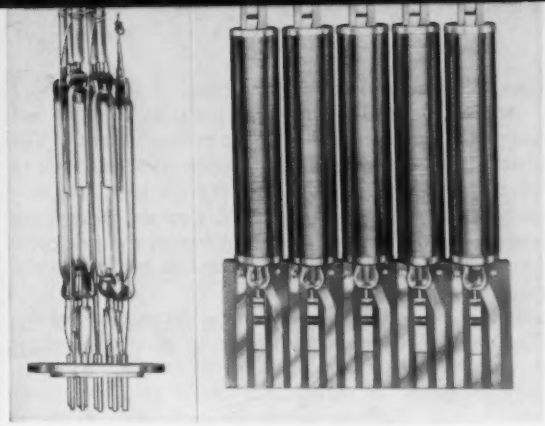
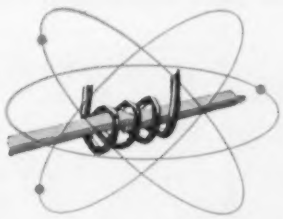


FIG. 3—Six Clareed relays are clustered for mounting in a single tubular container, left. At right, ten reeds are mounted in line, five on each side of printed circuit board

SWITCHING



operating time of 1.2 milliseconds[7].

Manufacturers and component research men foresee wide commercial application of the G-29 for low-level current switching[7]. A number of switches placed around a radar magnetron or electromechanical device, for example, provides a means of obtaining an accurate indication of the presence of a given magnetic field strength.

Another version of the contact capsule is the Unipole design of General Electric[8]. This tiny unit offers a contact rating of one or two amp for a nominal target of 500,000 operations, and features a double-throw contact. Models indicate mechanical life of 0.3×10^6 cycles and load life at one amp, 30-v d-c of 0.3×10^6 cycles. Many other designs are being investigated for both military and commercial use. Modified versions of contact capsules have been developed to improve current stability[9]. It is now a question of finding out how small these contacts can be made before running into trouble.

APPLICATIONS—Relays and other contact devices are found in practically all industries. The *USS Nautilus*, first atomic-powered submarine; the *USS Forrestal*, giant carrier; and automatic totalizing installations at all the nation's race tracks are examples of automatic controls where contact devices are in use.

There are many thousands of relays used in automatic telegraph switching systems which today blankets the country. Supervisory and control apparatus for power and pipeline systems, radio and television broadcasting equipment, traffic signals, radar, guided missiles and gunfire controls show use in increased numbers.

The growth of organizations that specialize in electromechanical devices combined with electronic systems (coin-operated ticket machines, racetrack totalizers, automatic transportation ticket issuing machines and the rest) shows that thousands of precision parts—mechanical, electrical and electronic—must be merged into a harmonious, dependable system. And our modern economy depends on coordinating engineering knowledge of mechanical electromechanical and electronics men[10].

MICROSECOND CONTROL—Search for design solutions involving electromechanical devices and electronic controls suffer from the time incompatibility between the two[11].

Inventors of the Ferreed tell that it was in this climate that a new class of switching devices was conceived at Bell. And today, the Ferreeds (cover), are among the most talked about contact-making devices.

Success with the contact capsules led investigators to seek a means of obtaining fast control of the metallic reeds in the G-29 capsule. And it was found that cobalt and cobalt-zinc ferrite cores could be wound to supply magnetomotive force that obtains reed control time of microseconds, coincident selection, a memory without holding power and a smaller, more sensitive unit.

This concept gives birth to a new family of contact relays. The ferrite member is controlled by the exciting current applied in microsecond time, and remanent flux alone is enough to control the reeds. The magnetomotive force that must be exceeded before sufficient remanent flux is produced is large enough to mask variations in reed sensitivity. And the unit can be used in coordinate arrays employing coincident selection.

As described by its inventors, the device offers an opportunity to determine directly the state of its output contacts: the device can be interrogated without the electrical output current being disturbed. Application of a short current pulse to the ferrite, and observation of induced voltage in another winding, can be used to deter-

mine the memory state of the device.

In one type, two ferrite bars, two G-29 capsules and two plastic end-pieces comprise the magnetic circuit. The plastic end-pieces magnetically couple the ferrite bars to the magnetic reed capsules, and provide structural support for the assembly. Magnetic flux passed through the reeds closes the circuit. Control pulses of five microseconds through the windings on the ferrite will switch the magnetic material.

The Ferreed fills the need for a network crosspoint that provides high-speed coincident selection with metallic contacts. At Bell, emphasis on the use of this device has been placed on optimization of the unit as a crosspoint switch. Various ties of Ferreeds suggest use in digital systems as memory devices for display, buffer and input-output functions. Capsules can be arranged with multiple-branch ferrite cores, or in combinations of magneto-motive force in multiple windings, such as for differential excitation.

Several new magnetic materials have been synthesized for cores. Among these are ferrites exhibiting characteristics midway between permanent magnets and computer memory materials, and ferrite suspensions in plastic tailored for specific properties.

The ferrite core is preferred for high speeds, since eddy-current delays remain in metallic structures, even when they are laminated. For lower speeds, metals offer better temperature stability.

The Role of Electromechanical Devices and the Circuit Function

Electromechanical devices such as relays and similar devices have already been developed, and can be expected to be further developed for telephone switching systems, military systems and automatic control systems in general that will be competitive, compatible and combinable with solid-state switching devices and systems.

At present, the best known and most widely used electromechanical device is the relay, used for general-purpose switching. Relays are the basic building blocks of todays telephone switching systems, as many as 5 or 10 may be used for each subscribers line. They perform many types of switching operations: multicontacts, slow and fast operation. slow release, marginal operation, a life of a billion operations, and many other functions.

Relay reliability in present telephone systems is such that one failure in 5-million operations is considered poor performance.

Stated another way, satisfactory operation for the average relay is less than one failure in 40 years.

It may seem strange that in a period when solid-state devices are being used increasingly in the area of switching functions, there are more relay manufacturers in the United States, and more relays are made and used than ever before. There are several reasons for this.

In many technical areas, often several competing devices meet the needs. The final choice is properly made in terms of many factors: speed, size, power, life, and more important—the cost. The cost factor must include not only the device itself, but all equipment costs needed for systems operation. Relays often result is systems designs which are simpler and less expensive and fast enough in operation to make unimportant any increase in speed of operation or release.

Relays can be used singly, or in small numbers, without the need of associated common control equipment which is often required where full advantage is to be taken of the sensational speeds of solid-state switching devices. In addition, the input and output circuits of a relay are completely independent, a condition not easy to achieve with solid-state devices.

The rapidly expanding applications of all kinds of switching systems requires more of all types of switching devices, including many kinds of relays and solid-state devices.

Compatibility of relays and solid-state devices is developing and in addition, combinational devices have recently been announced as illustrated by the Ferreeds. The fast Ferreeds do not need power to hold them in the operated condition.

Compatibility with solid-state devices, either as a relay or as a combinational device can be expected to be of increasing importance in the future. Compatibility will be required in size, power, life, speed and cost.

An important part of this new look for electromechanical devices will be the need for even greater reliability. This must not be determined by the average life to the point of 50 percent failure, but to the point of the first few failures—say the one percent or perhaps 1/10 percent failure point.

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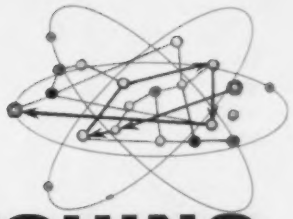

TRENDS IN MECHANICAL SWITCHING

Programs by industry and government indicate need for combining electromechanical and electronic approaches in integrated circuits. New devices will play an important role

CONTACT CAPSULE and the Ferreed indicate one direction that switching progress will take, for components using metallic contacts. And techniques will be worked out for the low-cost manufacture of these devices in various configurations and arrangements.

But more information is needed on overall switching and circuit-control concepts that will show how best to apply these concepts in circuits. Theories of switching with both contact devices and static elements should be translated into programs that show how to make use of the switching elements themselves.

Present programs leave many important areas undeveloped[1-2]. Fundamental investigations are needed to develop new switching techniques using dry-reed, mercury-wetted, liquid-contact and chemical relays, shift registers, and electrostrictive driving elements[3-5].

Switching action has been demonstrated in organic compounds and in synthetic membranes. The possibility of switching action in thin interfacial films is indicated. But at the present, as far as actual devices go, these switching concepts are somewhat advanced.

Printed circuit relay modules are on the market, Fig. 1; and so are removable wafers for switching, Fig. 2. Further studies are needed on printed relays for high temperatures, as well as improved methods to hermetically seal relay elements. A need is found for high-impact-shock circuit breakers for the 50-milliamp to 10-amp range; ruggedized choppers for printed circuits; and 0-200 second interval timers that have an accuracy of one percent or better.

Further study should be extended to develop faster response, more rugged thermistors for remote switching and control to implement thermal relays and thermocouples. New and improved measuring techniques for testing contact devices are also needed.

LOGIC FUNCTIONS—The Working Group on Electromechanical Devices, one of the eight groups under the Advisory Group of Electronic Parts of the Department of Defense, sees the trend of combining contact devices with electronic components in logic and switching functions such as counting, translation, registration, selection, scanning, and memory devices; and operations required for the organization and control of computers and other

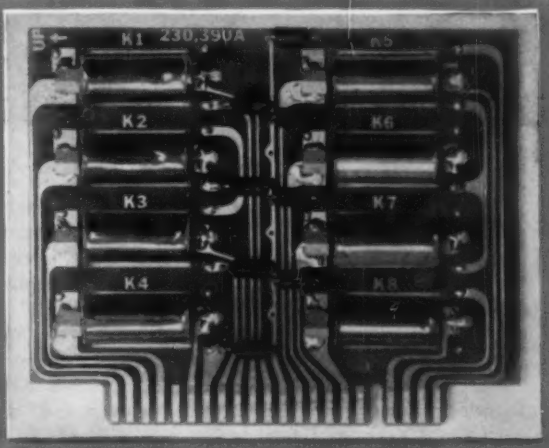

FIG. 1—Datex printed circuit relay module is used for data storage, code translation and digital-to-analog conversion. Module contains eight mercury-wetted contact relays and is designed for operation by transistor drivers

FIG. 2—Chicago Dynamics Industries switch with wafers that lift out for cleaning or replacement

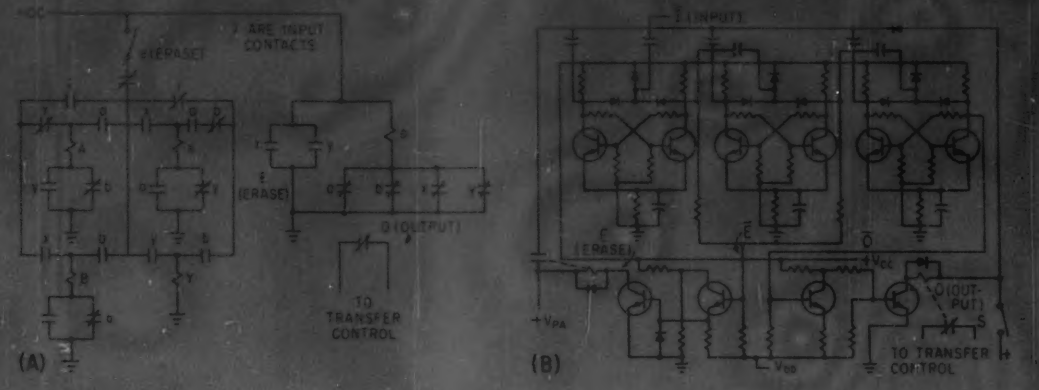

FIG. 3—Relay four-trip counter with erase features (A); and equivalent circuit designed with transistors (B)

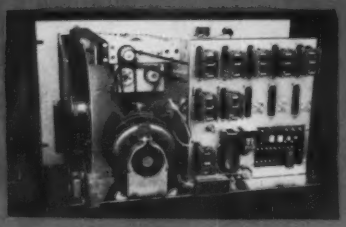

FIG. 4—Tally Register's transistorized tape perforator features transistorized gating of inductive circuits to provide drive to perforator from transistor logic

information processing systems.

The G-29 reed relays are now being evaluated for further study[8]. A crosspoint design using a two-coil magnetic latching relay of high sensitivity has been made and evaluated. An array of 4-wire crosspoints shows good transmission at carrier frequencies.

Latching relay structures for guided missiles are under investigation for a general-purpose, sensitive and power relay[7]. A spdt miniature time-delay-energize relay, for a one-to-60-sec delay, will operate between −65 and 125 C, 2,000-cps vibration, and take 50-g shock[9].

Work done for the Government has brought about a simplified six-part spdt relay that is readily adaptable to automatic assembly[9]. This design uses a permanent magnet for the deenergizing force.

A simplified relay requiring little or no hand labor in its assembly is being perfected[10]. And this program is working towards higher sensitivity, temperature and speed, and small size.

One company is working on a multipole device that has environmental resistances consistent with missile requirements, and sensitivities in the milliwatt range[11]. Experimental models employ a spring-wound energy storage system which drives an electromechanically controlled escapement mechanism. These models perform at actuating powers less than 3 mw in a package less than ¾ cu in. Small, sealed relays are also being developed to Relay Spec SCL-6304[12].

Design capabilities of the small, sealed, GE contact capsule is being investigated for an integral capsular relay that will stress power-handling capabilities and small size[13].

Many of these programs are in prototype stages and designers should not depend upon being able to obtain devices that are being developed under Government contracts.

In the United Kingdom, developmental trends in switching are in the direction of smaller size, greater reliability, and high shock resistance[14].

DISCRETE-VARIABLE CIRCUITS—These are used in telephone systems and have assumed increasing importance in modern electronic technology. The technology of telephone relays is highly developed, since these devices have been used for a long time. The art of manipulating information by electronics will continue to grow, and communication channels among research workers in switching techniques now allow evaluation of logical design[15].

Various methods of applying transient characteristics of sealed relays to predict their performance in systems have been investigated[16]. And last year, a progress report on relay testing measures was prepared that is a step towards thorough evaluation of reliable test techniques. This report contains a resume of investigations of low-energy tests; measurements of electrical characteristics; contact life testing; environmental testing; and shock, acceleration and tumbling tests[17].

THE INTEGRATED CIRCUIT—A trend towards combining contact relays with other elements make it advisable to think of component groups that do the job, rather than to select a component whose specifications will meet the functional requirements. For example, a 5 μsec switching requirement might be obtained by combining a contact relay with resistors, capacitors and diodes[18].

Predicted reliability of the contact relay approach is illustrated by a logic circuit within the control and protective panel of an electrical power system[19]. This small panel is a computer that controls and protects the main electrical system of a high-performance aircraft.

A four-trip counter was designed using contact relays,

TABLE I — FOUR TRIP COUNTER WITH ERASE FEATURE — RELAYS

Component	Qty	F.R.	Total F. R.*
Relays	7	1	7

* F. R. — failure rate in percent per thousand hours

TABLE II — FOUR TRIP COUNTER WITH ERASE FEATURE — TRANSISTORS

Component	Qty	F.R.*	Total F.R.*
Transistors	10	0.70	7
Diodes and Rectifiers	13	0.45	5.85
Capacitors	9	0.08	0.72
Resistors	32	0.10	3.20
Relays	2	1	2
	66		18.77

* F.R. — the failure rate in per cent per thousand hours.

Data taken from work done at General Electric Co. System used on the Electra turbo-prop commercial airliner[19]

MEMBERS OF THE NATIONAL ASSOCIATION OF RELAY MANUFACTURERS

Adams & Westlake Co.
AEMCO, Inc.
Allied Control Co., Inc.
Artisan Electronic Corp.
Automatic Electric Sales Corp.
Baso, Inc.
C. P. Clare Co.
Comar Electric Co.
Couch Ordnance, Inc.
Davis Electric Co.
Electro-Mechanical Specialties
Electro-Tec Corp.
Elgin National Watch Co., The Electronics Division
Filtors, Inc.
General Electric Manufacturing Co.
General Railway Signals Co.
Globe Electrical Manufacturing Co.
Guardian Electric Manufacturing Co.
G-V Controls
The Hart Manufacturing Co.
Hi-G, Inc.
International Business Machines Corp.
Iron Fireman Manufacturing Co.
Kellogg Switchboard & Supply Co.
Leach Relay Division, Leach Corp.
Magnecraft Electric Co.
North Electric Co.
Phillips Control Corp.
Joseph Pollack Corp.
Potter and Brumfield, Inc.
Price Electric Corp.
R-B-M Controls Division, Essex Wire Corp.
Sigma Instruments, Inc.
Struthers-Dunn, Inc.
Union Switch and Signal Division
Wheelock Signals, Inc.

Advances in relay-device design, as well as ideas and applications of these designs to switching techniques, are discussed annually at a Relay Conference sponsored by NARM. These meetings have been held at Oklahoma State University, Stillwater, Oklahoma and have had the support of C. F. Cameron and his staff at the University. Some of the relay developments discussed in this report were presented in papers delivered at these meetings

and a separate circuit was designed using transistors, see Fig. 3 A and B. Failure data, accumulated from several hundred-thousand hours of actual flight, is assumed constant, and does not include early failures or infant mortality losses or wearout failures. Tables I and II presents data on both systems. This example is not intended to show that the contact approach is the better, in every case, but that both approaches should be considered to evaluate each circuit problem.

PLANNING THE CIRCUIT—Many engineers put in systems design work want to replace all contact devices with diodes, transistors, magnetic amplifiers and vacuum tubes without first planning the circuit according to practical considerations of cost, temperature, power sources, and reverse voltage requirements[20].

New approaches to switching offer extreme sensitivity, microsecond switching, and life expectancy limited only by aging of the materials used[21]. And some high-speed switching devices could not justify presently available electromechanical devices. At the present time, these switching functions can be performed by solid-state switches that employ complex circuits.

But there is compatibility between the static device and the contact device, and advances are taking place in both areas.

PRINTED CIRCUIT BOARDS—These assemblies being used for mounting switching devices, they permit construction that is only one-half inch thick. In a new printed circuit board with mercury-wetted contact relays, power requirements are as low as 75 mw per switch, and speeds up to one msec are possible[22]. The printed circuit relay module is a simple approach to design problems.

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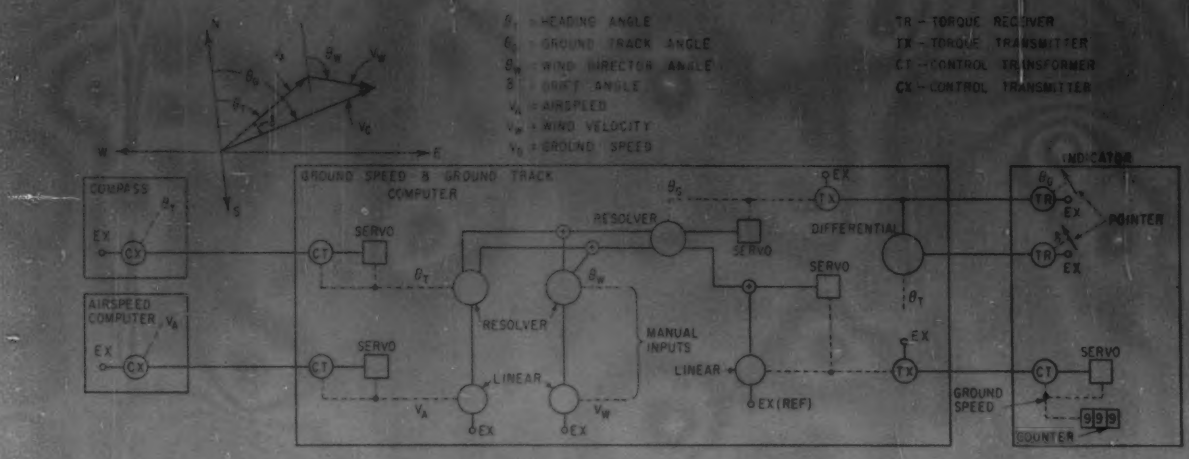
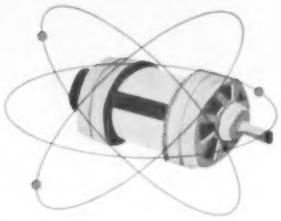


FIG. 2—Synchros, resolvers, and other components are used in a typical airborne computer to determine ground speed and other navigation information (Eclipse Pioneer Div., Bendix Corp.)



ROTATING ELECTROMECHANICAL DEVICES

SYSTEMS—DEVELOPMENT OF SERVOMECHANISMS and control theory brought with them the necessity for specifying overall system performance more precisely. Stability and system dynamics became new design parameters once the feedback loop was closed. The new requirements meant that more engineering time and effort had to go into the final product. Just as much thought had to be devoted to the system as a whole as was devoted to the individual components. At the same time the attention demanded by the individual components did not often become less.

With continued development, control and instrumentation systems have become increasingly complex and more precise, the temperature span has been increased, reliability has increased and size and weight have been reduced. The design problem has become more difficult and more factors have to be considered.

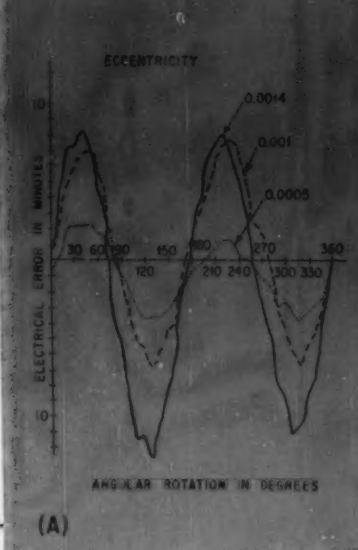
From the many instrumentation servos that were designed and built, it soon became apparent that some components typically showed up in systems in the same general way. The servomotor-tachometer generator is one example, and these two components were soon being built as an integral motor-generator package. The next step in this process has been the design and development of complete servo subpackages, with a set of specifications entirely different from previously available components. Figure 1 shows how these subpackages are used to build more complex systems.

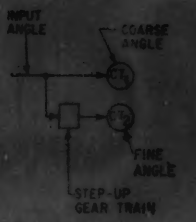
Common subsystems available are the synchro repeater, d-c voltage repeater and a-c voltage repeater, with each type available in several ranges of characteristics. Table I shows the characteristics of some repeaters. The data applies to systems in a 2-inch diameter case, with one 3-inch case included to indicate some of the differences to be expected from the change in size.

Most of the size 8 and larger components are available to build subsystems to this degree of miniaturization. (A size 8 motor is nominally 0.8 inch in diameter; a size 15 is 1.5 inch in diameter, and similarly for other components.) The next generation of subsystems will probably be size 5, but, as pointed out in the accompanying quotation, lack of suitable components is still a problem. Table II lists the size 5 components now available. The question marks mean that, so far as is known, no component of that type has met all required military specifiations.

It might seem that a size 8 system is small enough, that it is not worth while to go any smaller. But if it is assumed that system volume varies as the cube of the basic dimension, a size 5 system will occupy approximately one fourth the volume of an equivalent size 8 system.

In the design of high precision equipment, it is not the errors that set performance limits. Errors can be measured and compensated for but the unpredictable torques, moments and events—the uncertainties—can-





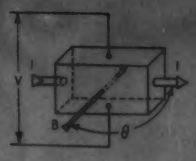


Table I—Characteristics of Repeaters

REPEATER TYPE			GENERAL PURPOSE	HIGH ACCURACY	HIGH SPEED	HIGH TORQUE
2" Case	SYNCHRO	Static Accuracy — Minutes	±18	±12	±18	±18
		Maximum Velocity — Deg/Sec	100	40	1600	20
		Stall Torque — Oz-In.	18	45	0.90	90
	A-C VOLTAGE	Static Accuracy — Percent	±44	±12	±0.8	±0.3
		Maximum Velocity — Deg/Sec	100	40	1600	20
		Stall Torque — Oz-In.	18	45	0.9	90
	D-C VOLTAGE	Static Accuracy — Percent	±44	±12	±0.8	±0.3
		Maximum Velocity — Deg/Sec	100	40	1600	20
		Stall Torque — Oz-In.	18	45	0.9	90
3" Case	SYNCHRO	Static Accuracy — Minutes	±36	±10	±24	±24
		Maximum Velocity — Deg/Sec	100	50	1200	25
		Stall Torque — Oz-In.	60	160	3	300

Table by Huyck Systems Co.

FIG. 3—Eccentricity between rotor and stator axes (A) is only one of the factors that contribute to error. Two-speed synchro system (B) reduces error. Hall effect synchros (C) can be used to determine θ

Rotating devices are small, reliable, are straining toward the 500C ambient level, with the size 5 miniaturized system a major target. Semiconductors have potential value in some applications

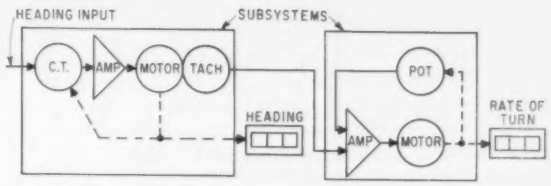


FIG. 1—Subsystems are combined in a typical aircraft instrument servo

not be compensated for, even though they may be recognized and probably measured. Uncertainty thus sets the limit on the precision that can be obtained.

In the most carefully built gyro, there will still be finite dust particles in the bearings. The fact that dust will be present is recognized, its effect on gyro performance is understood, but the instant when a given size particle will create an interference cannot be predicted. And the less dust there is, the greater the uncertainty.

It is in the reduction of uncertainty and the recognition of predictable errors that electromechanical devices as a group have made their most important advances. Devices today are significantly improved over even a few years ago.

SYNCHROS—Synchros are used in fire-control, navigational, instrument and other computers as replacement for mechanical elements. A transmitter-receiver chain can replace gears, sprockets, chains and shafts. Thus torques and angular displacements can be transmitted over distances with only wires as the connecting link. In addition, synchros can perform mathematical operations and, to some degree, serve as function generators.

Shown in Fig. 2 is the block diagram of an airborne computer that illustrates how the various types of synchros can be combined to solve a typical problem.

Synchro accuracy was about 1 degree in 1940, about 30 minutes in 1945 and is about 30 seconds today with the latest two-speed unit. A more conservative figure that would apply to standard production synchros today would be from 2 to 10 minutes. The improvement has come from steady engineering refinements.

A method that has been used to increase synchro accuracy is to use two units with gearing, as shown in Fig. 3B. One unit supplies coarse angular resolution and the other unit fine resolution. With a similar arrangement at the receiving end of the system, a theoretical reduction in system error equal to the gear train ratio is obtained. But much of the accuracy increase is lost in gear train errors. For example, using synchros with errors of 7 minutes, and an 11 to 1 gear reduction, an actual system error of about 2 minutes results. The gear ratio of such a system cannot be increased without limit because ambiguity of position would eventually result. The extra synchros and the gear trains also increase cost and require more space. System error changes as the gears wear.

A true double-function, or two-speed synchro has recently been developed. The device has two output signals, analogous to the output of the geared system; one synchro element makes one electrical revolution per mechanical revolution while the other makes 11 electrical revolutions. An odd number of cycles is used on the second element to eliminate the ambiguity that would otherwise result if the both signals had the same phase

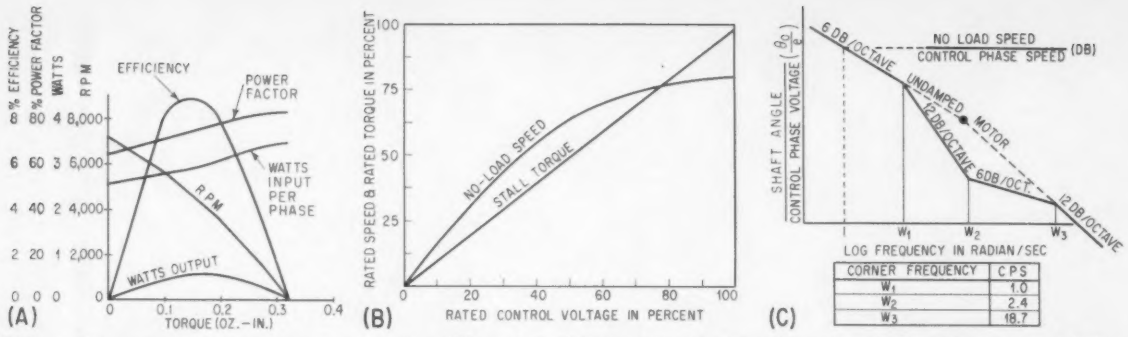


FIG. 4—Characteristics of a size 8 servomotor (Thomas A. Edison Industries) in (A) and control voltage characteristics of typical servomotors (B). Comparison of inertially damped and undamped servomotor (Beckman Instruments, Inc.)

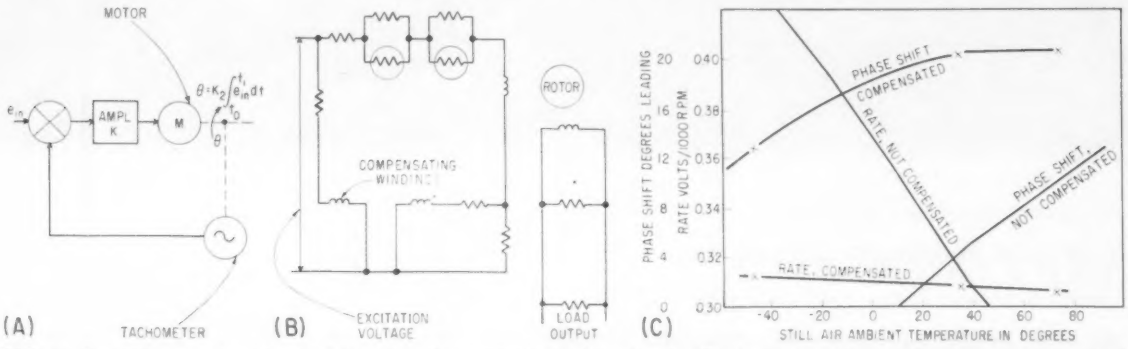


FIG. 5—Servo integrating circuit (A); thermistor compensating circuit (B) for a precision tachometer. Compensated tachometer has improved characteristics (C) with temperature change. Data was taken at 7,200 rpm

at the major nulls at 180 and 360 degrees.

The two-speed synchro can be built to have accuracies of 30 seconds, using the same manufacturing techniques and tolerances that result in 10 minutes of error in a single speed unit. One of the reasons for the improved accuracy is the elimination of second harmonic effects that are caused by uneven stresses in the magnetic structure. These stresses are generated by mounting clamps, temperature changes and residual stresses. The two-speed synchro was completely designed on a digital computer, with a consequent sophistication in design and a minimum of test and experimental work.

In addition to the multipole synchro, there are a number of approaches that are being investigated, including synchros that are essentially capacitive, optical, and air operated, and one that uses the Hall effect.

The Hall effect has been known since 1879 but has not been extensively applied because of the inefficiency of such devices with previously available materials. But in semiconductors the effect is multiplied 10,000 times compared with the best previous materials. Hall effect devices can be used as multipliers, to generate trigonometric functions, including sine and double-angle functions. Experimentation is continuing and it is believed that exponential functions will also be possible. The advantages of these devices are that they will be considerably smaller than present synchros and they should be another order of magnitude more accurate. The first unit of this type may possibly be in production within the next 12 months.

The basic Hall effect generator is shown in Fig 3C. The use of this device for synchro work depends on the equation $E = KIB\cos\theta$, where θ is the angle between I and B.

Linear synchros are similar to other types except that the output has been linearized about the null position. The usual sine wave output of a synchro can be linearized relatively easily to $\pm$ 45 degrees and this range can be extended to $\pm$ 65 degrees and higher but with increased departure from linearity. The same technique used in linearizing can be applied to obtain other functions; thus work has been done on the so-called linear synchro toward obtaining tangent, logarithmic and other functions. The shapes of the curves obtained can sometimes be varied with loading resistors and other circuit arrangements.

Synchros for operation at 500 to 600 degrees C are being investigated. The first phase has consisted of a study of materials and processes. No such synchros are known to have been built but the study indicated that such units are feasible.

Synchro test equipment has lagged behind synchro development, just as synchros have inevitably lagged behind system demands. Precision indexing devices—for testing synchros—today are accurate to $\pm$ 20 or 30 seconds and investigations are in progress to produce indexers accurate to one second or better. The difficulty of this problem is indicated by the fact that at 100 feet, one second of arc fans out to 0.69 inch. There is also a need for test equipment for field use. Field testers available today are basically the same equipment used in synchro production. Thus field test equipment is needlessly complex since it can measure many parameters the service man does not need to measure.

Table II — Availability of Size 5 components

Table by Huyck Systems Co.

		SIZE 8 SYNCHRO CONT. X-FMR				SIZE 8 SERVO MOTOR		SIZE 8 MOTOR TACH.		SIZE 5 PRECISION POTENTIOMETER			CHOPPER	
		400 CPS 11.8 V 11.8 mA	60 CPS 11.8 V 11.8 mA	60 CPS 90 mA	60 CPS 90 mA	400 CPS 26 W	60 CPS 90 W	400 CPS 26 W	60 CPS 90 W	1 TURN	10 TURN 10 mA AC	10 TURN 10 mA DC	400 CPS	60 CPS
STANDARD REPEATER	GENERAL PURPOSE		?		?	√	?							
	HIGH ACCURACY	?		?		√	?							
	HIGH SPEED		?		?			?	?					
	HIGH TORQUE		?		?	√	?							
A-C VOLTAGE REPEATER	GENERAL PURPOSE					√	?					√		
	HIGH ACCURACY					√	?				√			
	HIGH SPEED							?	?	√				
	HIGH TORQUE					√	?					√		
D-C VOLTAGE REPEATER	GENERAL PURPOSE					√	?					√	√	S
	HIGH ACCURACY					√	?				√		√	S
	HIGH SPEED					√	?			√			√	S
	HIGH TORQUE					√	?					√	√	S

√ COMPONENT AVAILABLE ? NO PROVEN COMPONENT AVAILABLE S SOLID STATE TYPES ONLY ARE AVAILABLE

One of the major problems in the application of synchros is the impedance mismatch between resolvers, linear transformers and control transformers. Another area where improvement is needed is in signal to noise ratio near the null position. In this respect, a synchro may typically have a 30 mv null while an equivalent microsyn unit will have a null of only 2 mv.

The microsyn is different from a synchro in that it uses a solid iron rotor instead of a wound rotor. In the microsyn both pickoff and excitation windings are located on the stator and the toothed or cogged rotor varies the coupling between the two sets of coils. These devices were developed especially for use with gyroscopes.

SERVOMOTORS—Shown in Fig 4A and 4B are the performance characteristics of a representative size 8 servo motor. The torque to inertia ratio has been improved in the past few years until it now approaches 100,000 radians per second per second. This has been a slow steady improvement and has resulted from continuing refinement in motor design. Another improvement has resulted from the use of special materials in the rotor to produce a compensated torque curve that is less sensitive to temperature changes. The maximum, or stalled torque, of a motor at 125 C with compensated design, will be 85 to 90 percent of its torque at 25 C. An uncompensated motor will have only about 65 to 70 percent of rated torque at 125 C.

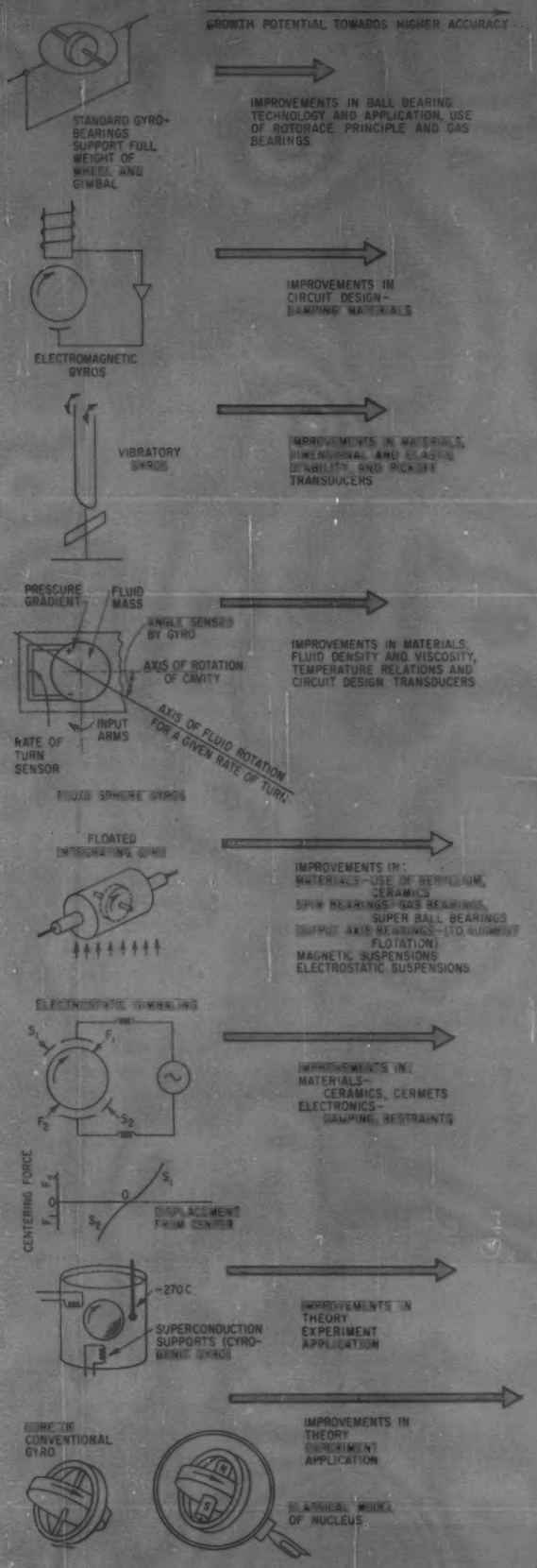
The life of the smallest instrument servo motors has been approximately doubled in the past few years. Motors are available now with guaranteed life of 2,000 hours at room temperature and 1,000 hours at 125 C. A few years ago they could be expected to last 1,000 hours at room temperature. Another recent development is the use of a magnetically coupled inertial damper. This development allows the rate feedback tachometer to be eliminated in some systems. The precision motor-tachometer combination is typically used in an integration circuit, as shown in Fig. 5A. The speed of the output shaft is controlled by the rate feedback system and the rotation of the output shaft is the integral of the input voltage over the time period it is applied. By using thermistors and opposing and aiding compensating windings, in the tachometer circuit, precision integrators can be made with an error of ± 0.5 percent over the range from -60 to 85 C. Further improvements can be expected with better compensating networks and with better materials compensation in the rotor and magnetic circuit.

The improvement in rate signal characteristics as a result of compensation is shown in Fig. 5C. The magnitude of the rate signal has been made almost flat and the phase shift has been improved.

A trend in servomotors is toward the use of special epoxies for the case. These materials have so improved in recent years that they can be used as motor and synchro housings. They are strong enough to support bearings and the only metal in the case is the faceplate that is used for mounting. With a slight negative coefficient of expansion with temperature, the epoxies actually improve performance with respect to temperature range. Size changes with temperature are less and outputs change less; this is of particular value with respect to precision synchros. Distinctive colors can be used and various color combinations such as stripes are feasible. An important result of the use of epoxies is that costs will be reduced.

Applications of small servo motors are primarily in instrument servos and in many types of computers, particularly in navigation and flight control computers. The usual supply frequency is 400 cps but there is some interest in going to still higher frequencies and some components have been made for operation at 2 Kc. The higher frequencies are particularly desirable when telemetry is involved in the system. Transmission of information is usually by f-m and the 2-Kc signal provides a greater deviation than 400 cps; the 2-Kc signal is therefore easier to detect.

TABLE II—Gyro Research. (Courtesy Sperry Gyroscope Company)


GROWTH POTENTIAL TOWARDS HIGHER ACCURACY
STANDARD GYRO-BEARINGS SUPPORT FULL WEIGHT OF WHEEL AND GIMBAL
IMPROVEMENTS IN BALL BEARING TECHNOLOGY AND APPLICATION, USE OF ROTORACE PRINCIPLE AND GAS BEARINGS
ELECTROMAGNETIC GYROS
IMPROVEMENTS IN CIRCUIT DESIGN-DAMPING MATERIALS
VIBRATORY GYROS
IMPROVEMENTS IN MATERIALS, DIMENSIONAL AND ELASTIC STABILITY, AND PICK-OFF TRANSDUCERS
PRESSURE GRADIENT
FLUID MASS
ANGLE SENSED BY GYRO
AXIS OF ROTATION OF CAVITY
INPUT ARMS
RATE OF TURN SENSOR
AXIS OF FLUID ROTATION FOR A GIVEN RATE OF TURN
IMPROVEMENTS IN MATERIALS, FLUID DENSITY AND VISCOSITY, TEMPERATURE RELATIONS AND CIRCUIT DESIGN TRANSDUCERS
FLUID SPHERE GYROS
FLOATED INTEGRATING GYRO
IMPROVEMENTS IN:
MATERIALS-USE OF BERYLLIUM, CERAMICS
SPIN BEARINGS-GAS BEARINGS, SUPER BALL BEARINGS
OUTPUT AXIS BEARINGS-LTO AUGMENT FLOTATION)
MAGNETIC SUSPENSIONS
ELECTROSTATIC SUSPENSIONS
ELECTROSTATIC GIMBALING
IMPROVEMENTS IN
MATERIALS-CERAMICS, CERMETS
ELECTRONICS-DAMPING, RESTRAINTS
CENTERING FORCE
DISPLACEMENT FROM CENTER
-270C
SUPERCONDUCTION SUPPORTS (CYRO-GENIC GYRO)
IMPROVEMENTS IN THEORY EXPERIMENT APPLICATION
SIZE OF CONVENTIONAL GYRO
IMPROVEMENTS IN THEORY EXPERIMENT APPLICATION
CLASSICAL MODEL OF NUCLEUS

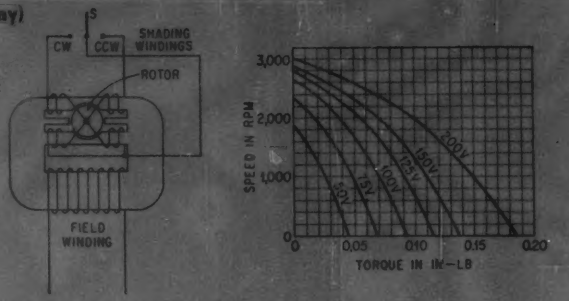


FIG. 6—Schematic (A) and speed-torque curves (B) for a shaded pole motor when operated as a two-phase servomotor (Barber-Colman Company)

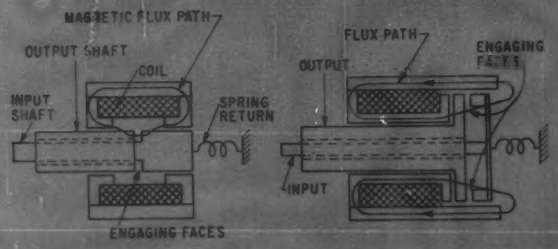


FIG. 7—Servo clutches engage when magnetic field operates to reduce air gap to zero. The arrangement in (B) will probably to used in size 5 units

SYSTEM DESIGN . . . .

"Accuracy, reliability, speed, size, weight and cost are each important to the system designer. A system with just one component that is inaccurate, unreliable or otherwise deficient can render the entire design impractical. On the other hand, new components, though they may represent an advance in the state of the art, may be of no practical use because matching components with comparable characteristics are not available.

As an example, potentiometers are available with resolutions measured in microinches, but mechanical effects such as bearing radial play and gear eccentricity make use of this characteristic impractical. Signficant advances in system performance are contingent, therefore, on significant advances in all component parts.

The accuracy of servo modules depends on gearing accuracy, servo threshold (a function of amplifier gain and motor starting friction) and the accuracy of the input devices themselves. In most applications the errors in available synchro control transformers are consistent with other errors but more accurate potentiometers in the ⅞ to 1⅛-inch diameter sizes are needed, particularly in the single turn type.

The development of servo modules smaller than the nominal 2 inch types now available is restricted primarily by the limited availability of size 5 synchros and motor-tachometers. Several potentiometers and 400-cps servomotors are now available in this size but these alone are not enough for a size 5 system."

JOHN B. HEAVISIDE
Standard Products Group Leader, Huyck Systems Company

For d-c applications, the permanent magnet motor with rectangular or flat construction has been developed in the past few years. Two opposed permanent magnets with the rotor between gives a configuration adaptable to this construction. For industrial applications, relatively low precision, inexpensive shaded-pole motors are often adequate. (Fig. 6A). Performance curves of a typical shaded-pole motor are shown in Fig. 6B. The motor is essentially a single-phase device and the two sets of shading coils provide a way to obtain either forward or reverse rotation with only a switch for control. By connecting the shading coils in series, operation similar to a two-phase servomotor is obtained. An electronic amplifier then drives the control winding.

Servomotors for industrial use are typically d-c, 50 or 60 cps but precision 400-cps equipment is so attractive that 400-cps power supplies can sometimes be justified. This trend is not extensive but is likely to be accentuated as automation continues and operations become more precise. There is also an increase in the use of d-c in industrial control systems.

Servomotors are also being constructed as two-speed devices, a high speed for fast correction of large errors and low speed for accurate nulling. In one case, a servomotor is combined with a digital or incremental motor. Another design uses electromechanical clutches to couple either high or low-speed gearing. Faster system response can be obtained in this way without a corresponding increase in instability.

CLUTCHES—The clutched servo has the advantage that it removes motor inertia from the control loop. Since the motor often contributes the major part of system inertia, the clutch system allows greater load acceleration. Not only is motor inertia removed from the loop, it now actually improves system performance, and it becomes practical to add a flyweel to the motor to increase power-source inertia.

Shown in Fig. 7 are two arrangements of a high-performance, magnetically operated, friction disk clutch, an important design in instrument-type servos. The clutch faces are typically metal, sometimes with serrations or teeth. Both arrangements shown have been used for size 8 and larger servo clutches, but the arrangement shown in Fig. 7B is the design that will probably be used to obtain a dependable size 5 unit. The difficulties in obtaining the size 5 unit are heat dissipation, dimensional stability with temperature changes and coil encapsulation problems.

The instrument-type servo clutch typically operates in less than 10 milliseconds but there are at least two other types that respond faster. The crystal clutch uses a piezoelectric material that changes dimensions when a voltage is applied. Useful torque can be transmitted within 0.2 millisecond of energizing. The crystal clutch is used in some specialized applications.

Another type of clutch that will actuate in 1 millisecond or less is an electrostatic type developed by IBM. It is not primarily a torque transmitter, however, but does find use in IBM equipment.

Suspended particle, or magnetic, clutches are not generally available in small sizes. The development problems are breakaway torque at low temperature and liquid seals at high temperatures.

GYROSCOPES—Gyroscopic force is inherent in any mass rotating about a self-contained axis. The earth spinning on its axis is a gyroscope but the moon rotating about the earth, the earth and planets spinning about the sun are not gyroscopic systems. There must be a rigid connection between all parts of the rotating system for gyroscopic reaction forces to occur.

The spinning wheel, most common of all practical gyros, is not the only way this force can be developed. An oscillating system, such as a tuning fork, also develoopes gyroscopic force, a principle successfully applied in the vibration gyro. Gyroscopes that would use piezoelectric and magnetostrictive properties are at least theoretically possible. Research is being done on instruments that would use these effects but there is little optimism that such instruments can be made more accurate or more useful than conventional types.

Typical free, or displacement, gyros are shown in Fig. 8. In Fig. 8B the addition of a viscous damping element converts a displacement gyro into a unit which integrates the amount of displacement. In Fig. 8C a spring return element gives a gyro which measures the rate of displacement.

Gyroscopes, because of the precision requirements of inertial guidance, have probably been brought closer to their ultimate perfection than any other electromechanical device. Shown in the chart are some of the techniques and concepts now being applied or being researched for future use.

The requirements of short range guided missiles are enough different from inertial guidance requirements that simpler and cheaper gyros can be used. Once fired, the missile life may be only a few seconds or minutes. Thus, freedom from long term drift is not an essential and power requirements are less stringent. Therefore a prewound spring or other simple means is used to set the rotor spinning at the time the missile is fired. The coast period of these simple gyros extends to ten minutes or more, by which time the mission is complete.

In Fig. 8A, the single degree-of-freedom gyro is supported, through the gimbal frame, by the bearings on the output shaft. Under conditions of zero input, the output shaft is stationary and metal-to-metal contact between the balls and the race of the bearing is established. Typically, two or three times the running force must be exerted to break the output shaft away from null. The magnitude of this break-away force, and thus the error introduced, is a function of the bearing coefficients and the weight of the gimbal-rotor structure, neither of which can be made zero.

In the floated gyro, the entire gimbal-rotor structure is enclosed in an inner housing with only the output shaft brought through to the outer housing. A fluid fills the space between the two housings and in effect floats the gimbal structure with respect to the support bearings. When adjusted and balanced, with float and fluid density made equal, with the center of gravity of the float mass and the center of buoyancy located at the same point, and with close temperature control, the reaction of the support bearings on the output shaft becomes smaller than can be measured. This remains true even under acceleration, with the result that jeweled bearings can be used at these points.

The vibrating gyro is an a-c counterpart of the con-

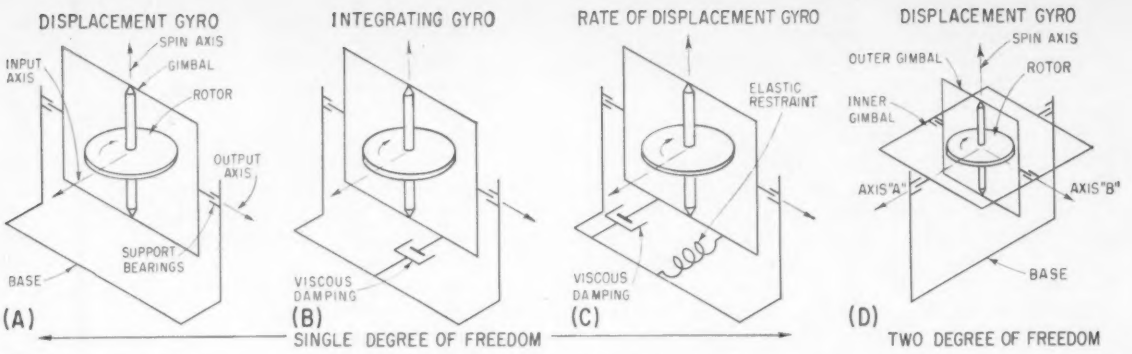


FIG. 8—The single-degree of freedom gyro (A), (B), and (C) is used primarily in inertial guidance, systems and computers of rockets and aircraft. The two-degree of freedom unit (D) is used in aircraft autopilots, short-term missile control, ships gyrocompass, oil-well drilling and land surveying

ventional rate gyro and uses vibrating masses instead of a rotor. In its simplest form, a tuning fork, the masses move in phase opposition in dynamic balance. When a rate of turn is applied about the fork's center line, the gyroscopic forces associated with the angular momentum of the tines produce an alternating twisting about this same axis.

The output signal is a-c and varies in phase and amplitude to indicate direction and magnitude.

Electrostatic forces may be used to support a gyroscope rotor. The electrostatic gyro appears promising for long space flights. Gas leakage into the evacuated gyroscope should not present difficulties because of the high vacuum of space. The amount of power required for the suspension system can be reduced to less than one watt per axis.

The cryogenic (magnetic suspension) gyroscope uses the principle of the repulsion of diamagnetic bodies by magnetic forces. When certain metals and alloys are cooled to extremely low temperature, they exhibit infinite electrical conductivity (zero electrical resistance). This property makes the superconductor diamagnetic. Diamagnetic materials have a magnetic permeability less than one and are repelled by magnetic forces; this force is used for suspension.

The fluid sphere gyroscope is a new instrument with a rotating fluid mass as the angular momentum element.

Elements of the instrument are a spherical cavity filled with a high density fluid and pressure sensitive pickoffs. The spherical cavity rotates at high speed and imparts motion to the heavy fluid through viscous shear. As the spherical cavity spin axis is displaced through a small angle, the fluid instantaneously slips relative to the cavity to retain its original momentum direction. But the fluid has finite viscosity and will exponentially realign with the cavity spin axis. Thus the device is inherently a rate gyro with a time constant (a typical value is 0.5 second). When the momentum axis of the fluid is not aligned with the cavity spin axis, a differential pressure occurs across the undisturbed fluid outside the cavity.

Various subatomic particles possess angular momentums characteristic of their energy states which are equatable to gyroscopic properties. In fact, certain types of particle phenomena can be explained conveniently only by taking gyroscopic properties into consideration.

Unlike the conventional gyro wheel that must be supported and powered, the nuclear gyro has an angular momentum which is self sustained.

Like the conventional gyro, the spinning particle must be oriented initially, it must then maintain this orientation and the orientation must be detected or sensed. Each atomic nucleus is suspended in matter—as if by the gimbaling system of the conventional gyroscope. Under ordinary conditions the spin axes are randomly oriented, making detection of the coordinates of any one particle extremely difficult. Accordingly, the trend of research is directed toward finding a way to orientate the millions of nuclei in a sample and to detect their gyroscopic properties collectively. The atomic gyroscope, if successfully developed, can be expected to use techniques similar to those developed for atomic clocks.

ACCELEROMETERS—Accelerometers are used in vibration studies of aircraft, missiles and rotating equipment, in inertial guidance systems and in geophysical studies. Accelerometers for studies of the earth's gravitational field can detect variations in the earth's gravitational constant as small as 10^{-8} g. For vibration studies and other uses, units are available that measure accelerations to several thousand g's.

Accuracy of the simplest types is usually about 1 percent, adequate for vibration studies but unacceptable for inertial guidance, where integrations of acceleration and velocity determine distance traveled. The flotation principle developed for gyros is also used in high precision accelerometers.

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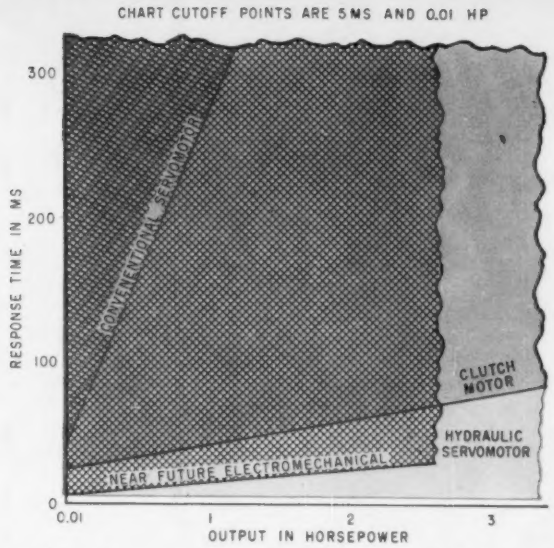


FIG. 1—A comparison of actuators as a function of horsepower and speed of response to a step function input. The curves are approximate. Chart was prepared by Airborne Accessories Corp.

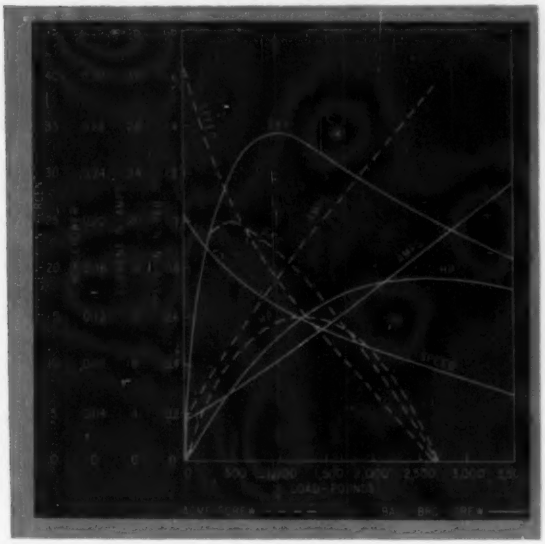


FIG. 2—Performance curves for a 26 volt d-c linear actuator. Solid curves are for a conventional screw, dotted are for a ball-bearing screw

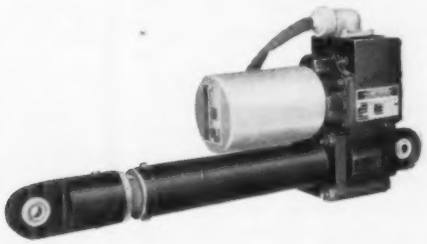


FIG. 3—Actuator, manufactured by Airborne Accessories Corp., has the performance shown in Fig. 2. Maximum load is 2,500 pounds, weight is 5.44 pounds, unextended length is about 8 inches, stroke is approximately 6 inches

ACTUATORS AND TIMERS

Electrochemical actuators have been refined for more flexibility and faster response, may be used more extensively in next generation of rockets and missiles. Timers, valves, solenoids have been made smaller, more reliable

ACTUATORS—THE SYSTEMS ENGINEER is typically faced with the problem of which actuator to use. The answer is seldom clear cut and in many cases any of several solutions may be acceptable. Common types of actuators in high performance, critical weight areas such as missiles and aircraft are hydraulically driven devices and electromechanical devices such as rotary or linear actuators. In addition, the electronic or electromechanical servo system is used to solve the problem, sometimes with a hydraulic power element and sometimes with an electromechanical power element.

Characteristics of the three types of systems overlap, with the main performance factors being speed of response and horsepower. Fig. 1 shows the characteristics of the three systems today. The hydraulic system has the greatest speed of response for a given horsepower; hydraulic actuators can also handle power almost without limit. But at low power, electromechanical devices can operate almost as fast as a hydraulic system.

Performance curves of a representative electromechanical actuator are shown in Fig. 2, with a conventional screw and a ball-bearing screw. High performance actuators are primarily available for use with 400 cps or d-c. Some actuators for 60-cps operation are available but the range and variety is not as extensive as for 400 cps and d-c. Gearhead motors and similar arrangements are typically used in industrial applications, where cost is usually important and weight is usually unimportant.

A trend in actuators is toward the use of clutches and a motor that runs continuously. The technique removes

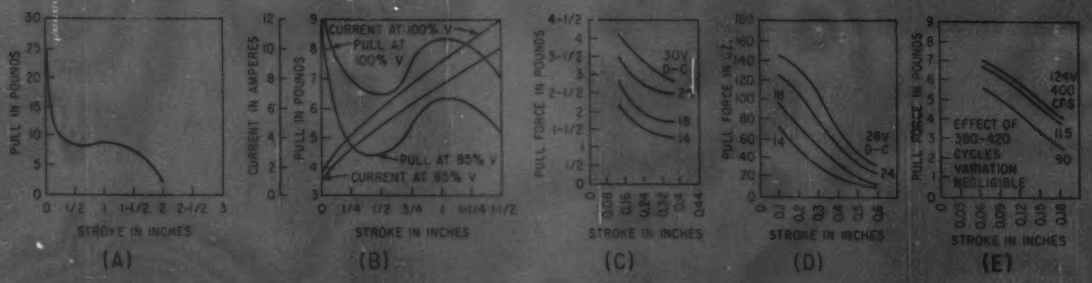


FIG. 4—Force-stroke curves of typical solenoid: 10 w-ft d-c (A) and special a-c solenoid (B) by Automatic Switch Co.; d-c solenoids (C) and (D) and 400 cps unit (E) by G. W. Lisk Co.

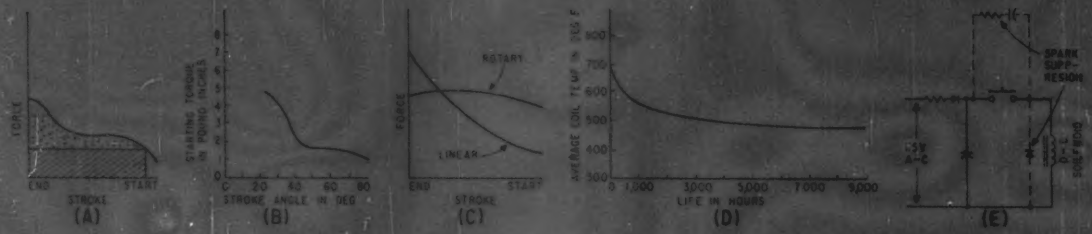


FIG. 5—Total area under the curve (A) represents energy available from solenoid while cross-hatched area represents work delivered to the load. Starting torque as a function of stroke angle (B) for G. H. Leland (Ledex) rotary solenoid type 6S. Shaped force-stroke characteristic of rotary and linear solenoids (C). Life expectancy curve (D) of a high-temperature solenoid manufactured by G. W. Lisk Co. Spark suppression methods and simple rectifier circuit for a-c use (E). If the pushbutton is placed ahead of the rectifier filter network, the actuation speed will be decreased by the time delay effect of the filter capacitor.

the motor inertia from the loop and increases system response speed. The increased speed is significant, since it increases the overlap of electromechanical and hydraulic devices.

One clutch technique uses the clutches in a dither mode, with a forward and a reverse clutch alternately energized in rapid succession when the system is at null. Although this scheme would require changes in the control circuits—the output signal being forward and reverse driving pulses of varying widths—it produces several advantages, including minimum dissipation of the output stage, maximum positioning accuracy and minimum deadband.

SOLENOIDS—The d-c solenoid is probably the simplest of all electromechanical devices. A coil of wire forms the electrical circuit and a solid iron core or armature is the mechanical structure. A magnetic circuit for flux is not essential to the design, but because it contributes to efficiency and power rating, it is almost always an integral part of solenoids.

Solenoids for use on a-c differ in design from d-c units chiefly in that the a-c units use a laminated magnetic structure to reduce eddy current losses. Shown in Fig. 4 are some force-stroke curves for both a-c and d-c solenoids. Both types have minimum force at the beginning of their stroke and maximum force when the armature is seated and the air gap of the magnetic circuit is reduced to zero. One of the a-c curves shows a double-valued function that was specially designed into the unit. Many, but not all, a-c solenoids have this type of characteristic. A somewhat similar characteristic can be designed into d-c solenoids as is shown by one of the curves. The relatively long-stroke, flat characteristic of the d-c unit was obtained by using a tapered plunger.

Shown in Fig. 5A is a typical solenoid curve with the load characteristic superimposed. The work done by the solenoid is force times distance and is represented by the total area under the curve. But work done on the load is represented only by the cross-hatched area. The excess energy goes into load acceleration and into a hammer blow at the end of the stroke that is absorbed by the plunger and the solenoid frame. If the solenoid is much too large for the load, hammer blow increases and the life of the device will be shortened rather than lengthened. The curve also illustrates that solenoid force must be greater than load reaction force throughout the stroke.

The development of the rotary solenoid meant that a new device was available that had unique characteristics.

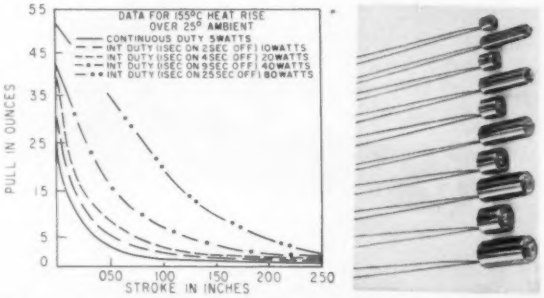

DATA FOR 155°C HEAT RISE OVER 25° AMBIENT
CONTINUOUS DUTY 5WATTS
INT DUTY (1SEC ON 2SEC OFF) 10WATTS
INT DUTY (1SEC ON 4SEC OFF) 20WATTS
INT DUTY (1SEC ON 9SEC OFF) 40WATTS
INT DUTY (1SEC ON 25SEC OFF) 80WATTS
PULL IN OUNCES
STROKE IN INCHES

FIG. 6—Characteristics of a d-c solenoid ½ inch in diameter and ½ inch long, by Anderson Controls, Inc.

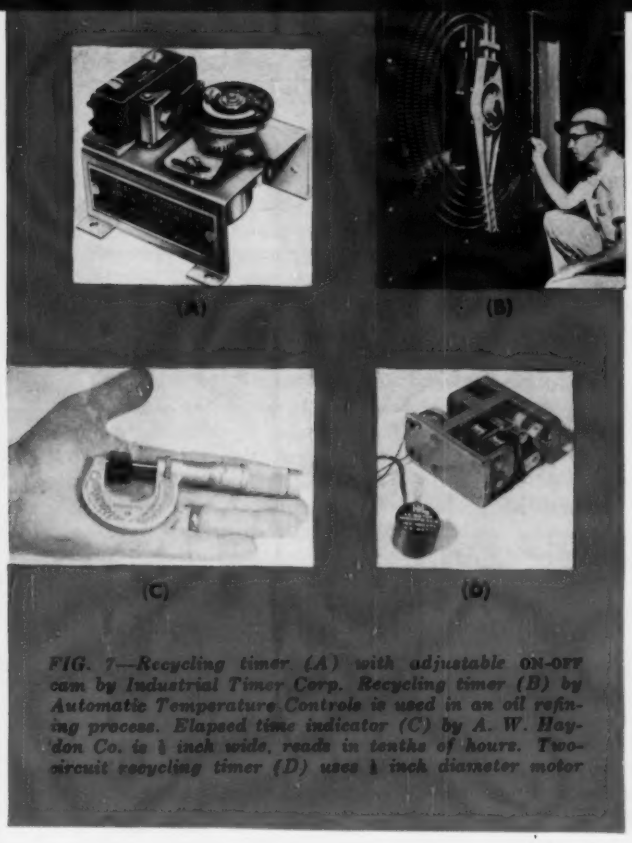


FIG. 7—Recycling timer (A) with adjustable ON-OFF *cam by Industrial Timer Corp. Recycling timer (B) by Automatic Temperature Controls is used in an oil refining process. Elapsed time indicator (C) by A. W. Haydon Co. is ½ inch wide, reads in tenths of hours. Two-circuit recycling timer (D) uses ½ inch diameter motor*

It is essentially a d-c solenoid but linear motion is converted to a rotary motion. This is done by constraining the plunger to move along an inclined plane as it closes. Since the closing force must work against the inclined plane to obtain rotation, the total angle over which the plunger turns affects the torque output. The starting torque for one rotary solenoid is shown in Fig. 5B.

The inclined plane concept gives the solenoid designer an extra variable to use in shaping the force-stroke curve. By inclining the plane steeply at the beginning of the stroke, where the closing force is weakest, and making it less steep as the air gap decreases, an almost straight line characteristic can be obtained as shown in Fig. 5C.

Many standard off-the-shelf solenoids are available, both a-c and d-c. However, optimum results are usually obtained with custom engineered units.

Because of simplicity, it has been possible to design solenoids for high temperatures. Solenoids for use in nuclear energy installations have been built that will operate continuously at 1,000 F. The life curve for another relatively high temperature solenoid is shown in Fig. 5D.

Inductance of d-c solenoids is inherently high and spark suppression across the operating switch may be necessary. This can be accomplished in either of the two ways indicated in Fig. 5E, which also shows a simple rectifier circuit that is satisfactory with a-c operation.

When fast operation is desired, a series resistance bypassed with a capacitor will provide the coil with an initial overvoltage. The series resistor limits holding current to the required value, which may be less than normal rated current.

Operating characteristics for a size 5 solenoid are shown in Fig. 6. The unit is ½ inch long—one of a series—and several mounting arrangements are available.

TIMERS—There are three basic types of electromechanical timers. One is a motor driven cam that operates a switch or a set of contacts. A second opens or closes a set of contacts a given time after the timer is energized. The third is the elapsed time meter or time totalizer.

Many variations of the types are available. Shown in Fig. 7A is a recycling timer with an adjustable cam. The ON or OFF time can be adjusted from 2 to 98 percent of the total time cycle. One complex timer of this type is shown in Fig. 7B. There are 900 contacts in each ring and 3,600 contacts on the plate. Timers of this type have been built with as many as 7 rings and 6,300 contacts. The individual contacts are wired to a patch board where the circuit closures are selected. Typically, not all the circuit closings are needed and only those required by the process are used. Because the arm is balanced and moves slowly, the timer can be driven by a clock motor.

Timer developments in recent years have been toward better appearance, standardization, and more flexibility. Plastics are being used extensively, testing is more thorough, plug-in construction is available.

The plug-in feature allows production downtime to be reduced when a timer fails, but it is not an unmixed blessing. In a production control system the timer is often the least understood piece of equipment and the first suspected of being defective. There is a tendency to try a replacement timer at the first sign of trouble, particularly when the origin of the trouble is not clear. But if the controlled process has not been completed, a replacement timer may start the process over again from the beginning. Loss of material may result and dangerous conditions could develop, if the process has that capability.

Military and space problems have required miniaturization. The miniaturization obtained is indicated in Fig. 7C, which shows an elapsed timer ½ inch wide that reads to 999.9 hours. The motor to power this timer, shown in Fig. 7D, is an 8-pole, synchronous motor for operation on 115 volts, 400 cps at 3,000 rpm. It weighs ⅛ ounce and develops 1.5 microhorsepower.

The use of elapsed time indicators has been increasing because of the reliability problem. It is desirable to monitor the service hours of some components so replacements can be made before a system failure results.

In the countdown for the Titan missile there are three critical steps that affect the total countdown period. In normal procedure, the three points are passed one after the other on a planned schedule. But if these critical points occur before or after their planned time, a countdown timer, Fig. 9B, speeds up or slows down to bring the countdown into step with the critical synchronizing events.

Another development is the use of an escarpment with a d-c clock motor. This is not the spring-winding device of automobile clocks but a pulse driven d-c motor. The chronometric movement carries contacts that supply variable width pulses to the motor approximately 15 times per second. A d-c clock of this type can be adjusted to an accuracy of 3 to 5 seconds a day, under essentially ideal conditions. Under 10 g vibration at 300 cps, accuracy is 0.5 percent.

Shown in Fig. 9D is a multipurpose timer for missiles. An unusual feature of the timer is that it is started by

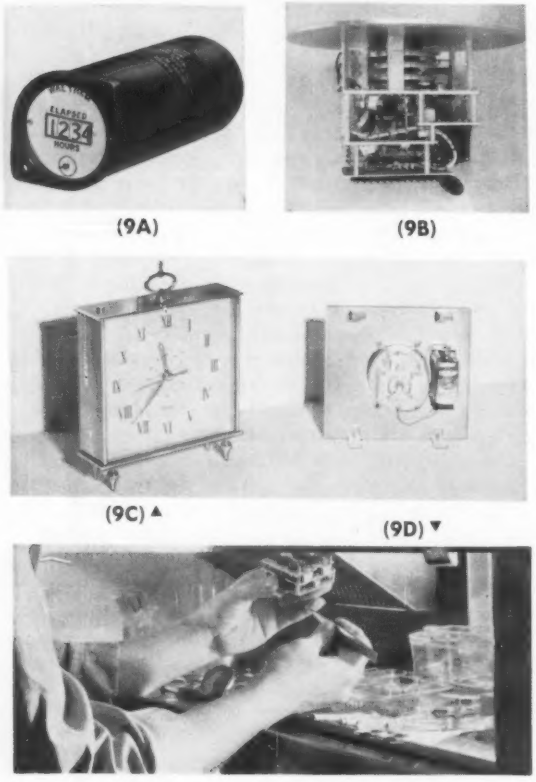
On Actuators

In response to a question about the limit of complexity or sophistication for high performance actuators:

"I do not believe it is possible to forecast a limit of sophistication for these devices. Actuators being built today are many times more sophisticated than those of even the recent past. They incorporate such features as load limiting and position limiting, they provide a wide variety of force versus displacement characteristics, all tailored to the needs of a particular application, and they incorporate a wide variety of feedback and signaling devices. Even so, they remain relatively crude when contrasted with the muscles and feedback devices of man.

They excel in speed, power and positioning accuracy but are deficient in sensitivity. Perhaps the most sensitive actuators so far built are those used in remote handling equipment for radioactive material. Even a cursory study of these mechanisms shows, however, that they have a long way to go if they are to equal the versatility and sensitivity of the human. The chief shortcoming of existing actuators is probably in the area of transducers. In general, our present day actuators respond as muscles to some transducer signals, properly amplified, with the idea that if the actuator performs by rote some predetermined action, the error signal from the transducer will be corrected. There is no attempt to put secondary systems transducers in the actuator that would give it a chance to interpret its order with any degree of intelligence. The closest we have come to this requirement is the incorporation of so-called load limiting schemes in the actuator gear train or structure. These prohibit the actuator from exerting a force beyond some preset amount. Usually this preset amount is something just below the point of structural failure, either for the actuator or for the device it is moving, and well above normal operating requirements."

C. N. HOOD II
Director of Engineering, Airborne Accessories Corporation



(9A) (9B)

(9C) ▲ (9D) ▼

FIG. 9—Elapsed time indicator by Waltham Precision Co. (A) reads to 9,999 hours, has mounting centers a little more than 1 inch apart. Countdown timer (B) by Automatic Temperature Controls for Titan ICBM firings. Clock by Sessions (C) uses A. W. Haydon chronometrically controlled d-c pulse motor for wireless electric operation. Timer for missile applications by Bulova Research and Development Labs., Inc. (D)

explosive charges. Additional details have not been made available.

Electromechanical timers tend to be rugged, inexpensive, and, when the timing period is relatively long, (10 seconds or longer) more accurate than electronic units. In addition, the electromechanical timer can produce complex switching sequences and handle load currents to 25 amperes. One proposed timer, which is not a production unit, would use a combination of electromechanical and electronic circuits as shown in Fig. 10. A timer of this type would have high accuracy and would operate over long periods of time.

SOLENOID VALVES—A small solenoid valve, approximately ⅜ inch in diameter and about 1⅜ inch long, was developed for automobile use but is being investigated for other applications. Because of its fast operation —open and close cycle in 6 milliseconds—the valve should be useful in certain hydraulic circuits where accurately timed control sequences are necessary. One possible use is in the volumetric control of fluids and gases. In this application, which is being investigated, a pulse width modulated signal controls valve operation.

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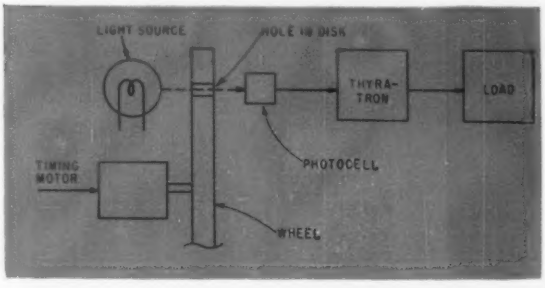
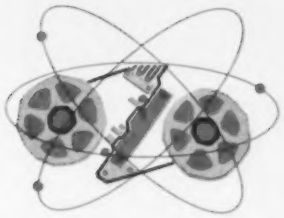


FIG. 10—Possible way to obtain accuracy over a long time period would combine electronic and electromechanical elements



Counters and recorders are more flexible; printout devices are faster and are approaching the limits of present-day magnetic tape transports. This field is bustling with activity; here is a sampling of new developments

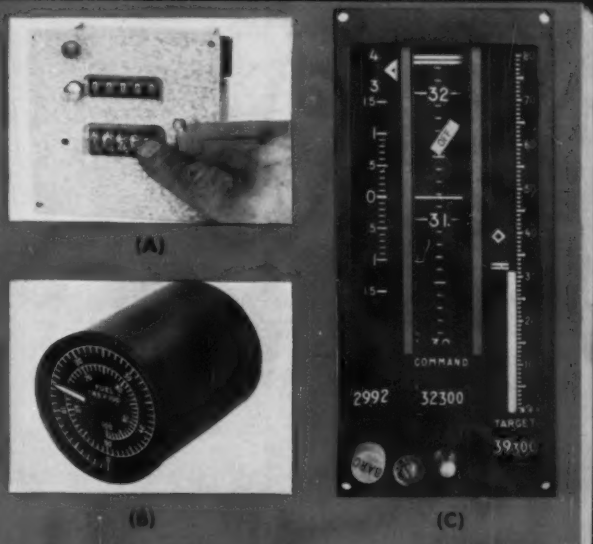


FIG. 1—Bidirectional counter (A) available from Presin Co. Aircraft instrument (B), Bendix Corp. Spiral scale indicator (C), Liquidometer Corp.

ELECTROMECHANICAL READOUT

ELECTROMECHANICAL COUNTERS have not been significantly miniaturized in recent years, although some readout devices have, as discussed in this report under TIMERS. Some new features have been added, however, including bidirectional counting and the addition of a limited number of switching circuits for control at preset counts. Shown in Fig. 1A is a double-limit, predetermining counter. It accepts random forward and backward operating pulses without loss of count and closes a contact at a preset count and another contact at zero. The device has applications in digital quality control systems, and warehouse and parking-lot operations.

A new approach in counters is toward single wheel counters which close a circuit in the home or zero position. Single units can be stacked side by side to obtain as many digits as required.

INDICATORS—In high-precision equipment, readout is often digital or as servo-driven tapes, as shown in Fig. 1B. The tape increases scale length from a few inches to several feet or more, while digital presentation provides essentially infinite resolution. Another means of increasing scale length is shown in Fig. 1C, where a spiral scale is used. The pointer length varies as it moves so that no ambiguity develops as to which part of the scale to read. Instruments of this type are backlighted, with reduction of glare and enhancement of readability. Lucite is used to pipe light to the pointer, so that the pointer is

FIG. 2—Miniature printer (A), by Potter Instruments, in 3-inch diameter case. Printout system (B), by Analex Corp., operates at 1,000 lines per minute. Printer-plotter (C), by Briggs Associates, Inc., produces 4,000 lines per minute or draws ten graphs

also illuminated for greater readability.

PRINTOUT DEVICES—A major limit on digital electronic computers is the speed at which information can be fed in or read out. As a result of this limitation, printout devices are operated either on-line with summary results only or off-line. In on-line summary operation, the computer operates on the input information, uses an internal memory system and prints out only the final answer. Answers to intermediate steps in the problem solution are discarded. In off-line operation, the computer generates a series of answers faster than printout devices can follow and the answers are transferred at high speed to magnetic tape. The tape is then run at a slower speed through the printout device, where customer invoices, inventory lists, payroll checks and other forms are prepared. The time saved is significant and allows maximum use of the computer.

Tape transports have recently been developed that record 2,000 bits per inch and process tape at 150 inches per second, giving 300,000 bits or characters per second. This is an effective computer clock rate of 300 Kc, as compared to a clock rate of about 6 Kc approximately four years ago. There is a continuing effort to push this rate higher and higher.

Shown in Fig. 2A is a miniature, high-speed printer that operates at 1,800 characters per minute. It uses pressure sensitive paper tape and a character wheel that rotates at 30 revolutions per second (1,800 rpm). When the character to be printed is in position, a solenoid driven hammer brings the paper into contact with the wheel and the information is transferred. The paper is driven continuously at 3 inches per second and is not stopped during the print operation; one character is printed during each revolution of the wheel, which determines the operating speed of 30 bits per second. Decoding circuits for the parallel entry digital signal are transistorized and self-contained.

The rotating print wheel concept is also used in printout devices of the type shown in Fig. 2B. Output speed has been increased in recent years to 1,000 lines per minute for alphanumeric readout, with as many as 160 characters in each line. A separate character wheel and hammer are used for each character in the line. When only numeric characters are used, operating speed can be increased to 2,000 lines per minute.

One design idea is to use cards instead of magnetic tape for input to the printout device. Cards can first be automatically sorted, then printed out, an advantage in some applications. Typically, each card generates one line of output. Operating speeds for card-fed print outs range from 700 to 2,000 cards per minute. There has been a strong push toward more economical printout devices and one firm recently announced price reductions of 40 to 50 percent on some of their equipment.

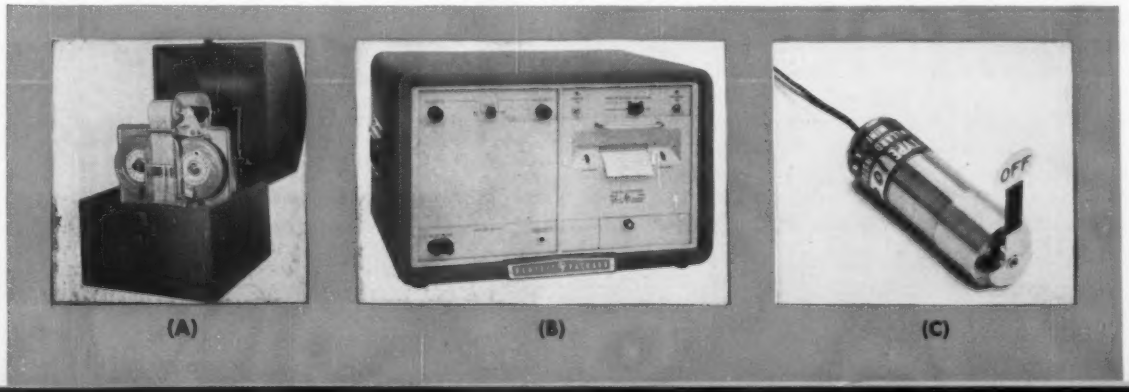
A different type readout device is shown in Fig. 2C. Although it operates from magnetic tape input similarly to other types, the output can be either lines of printed material or graphs. The output mechanism consists of 1,024 needle type styli strung across a ten inch strip of paper, giving an output signal density of 102 points or dots per inch. The styli are individually energized by control amplifiers and an electrolytic action takes place between the paper and an iron anode, resulting in deposition of iron ions on the paper with consequent discoloration. As many as 10 graphs or curves can be plotted simultaneously, with an accuracy of 0.05 percent of scale width. At the same time, grid lines, scale factors and annotations are drawn in.

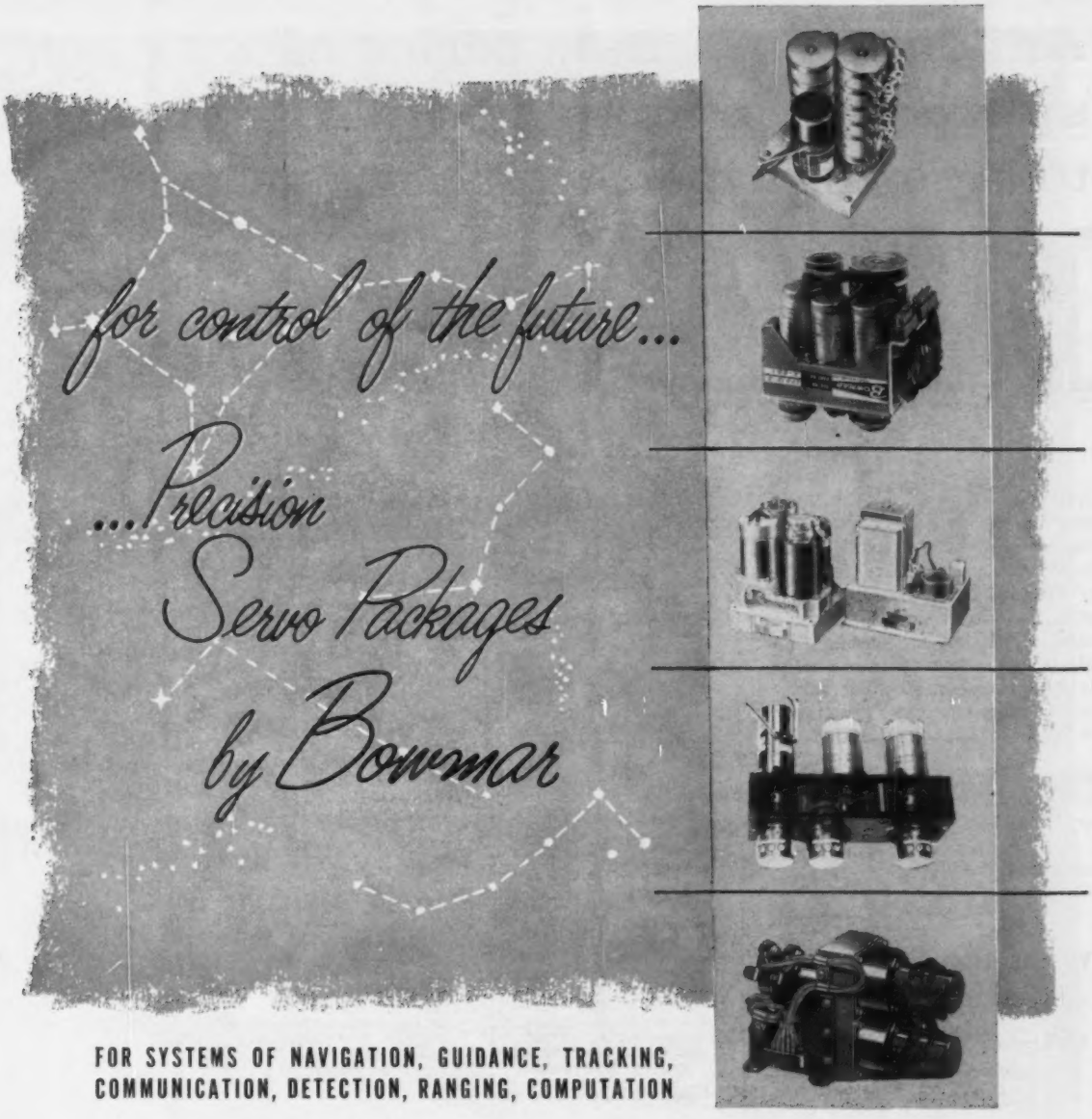
Letters and numerals are formed by energizing styli that will give the desired pattern. Maximum printing speed is a 4,000 lines per minute. A 2,400 foot roll of digitally coded magnetic tape can be read out in approximately eight minutes, giving 500 pages of graphs and/or printed matter.

RECORDERS—Shown in Fig. 3A is a recorder which stores data in digital form on paper tape. Input can be in continuous analog form as would be obtained from a liquid-level measuring system, or it can be essentially digital information, as in traffic or pulse counting. The code wheels generate a digital signal from rotation of the input shaft. Each revolution of the input shaft generates 100 bits. A gearing ratio of 100 to 1 between the two code wheels allows counts up to 10,000. When the recorder is used for traffic counting, it can be set to make sample counts every 15 minutes. Readout is in three forms: visual from markings on the wheels; electrical contact closures for telemetering or control; punched tape for storage and later analysis. The recorder operates on a 6 volt battery for portable use but is also available for other voltages.

An 11 bit digital recorder is shown in Fig. 3B. In addition to printout, it gives a simultaneous analog output.

FIG. 3—Punched tape recorder (A), by Fischer and Porter Co., is used in traffic recording. Digital recorder (B), Hewlett-Packard, also has analog output. Electromechanical indicator (C), by Allard Instrument Corp., can be fitted with specially designed flags





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- **Max. power output (watts):**
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Embraces high torque/watt ratio and adequate acceleration characteristics. Stall Torque, .35 oz-in.; Rotor inertia, .66 gm.-cm²; Acceleration, 37,000 rad./sec.²; No load speed, 6500 rpm; Damping coefficient, 36 dyne-cm-sec/rad.; 3.0 watts/phase @ stall.

lo-*J*

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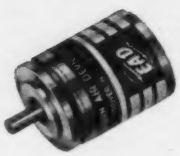


SERVO MOTORS with TACHOMETER GENERATORS

hi-*T*

Stall Torque, .35 oz-in.; Rotor inertia, .72 gm.-cm²; Acceleration, 34,400 rad./sec.²; No load speed, 6200 rpm; Damping coefficient, 38 dyne-cm-sec/rad.; 3.0 watts/phase @ stall; Gen. output, .250 v/1000 rpm; Phase shift, ±10°; Null voltage, 10 mv.; Gen. input, 1.7 watts.

lo-*J*

Rotor inertia, .23 gm.-cm²; Acceleration, 77,000 rad./sec.²; No load speed, 6200 rpm; Damping coefficient, 27 dyne-cm-sec/rad.; Gen. output, .250 v/1000 rpm; Phase shift, ±10°; Null voltage, 10 mv.; Gen. input, 1.7 watts. Stall torque, .25 oz-in.

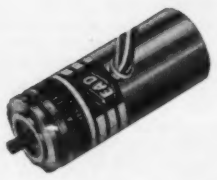
SERVO MOTORS with INERTIAL DAMPERS

hi-*T*

Stall torque, .35 oz-in.; Rotor inertia, 1.0 gm.-cm.²; Acceleration, 24,700 rad./sec.²; No load speed, 6000 rpm; Damping coefficient, 39 dyne-cm-sec/rad.; 3.0 watts/phase @ stall; Flywheel damping, 60 dyne-cm-sec/rad.; Corner freq., .98, 2.8 and 18.5 cps.

lo-*J*

Rotor inertia, .54 gm-cm²; Acceleration, 32,700 rad./sec.²; No load speed, 6000 rpm; Damping coefficient, 28 dyne-cm-sec/rad.; Flywheel damping, 60 dyne-cm-sec/rad.; Corner freq., .77, 2.8 and 16.4 cps. Stall torque, .25 oz-in.



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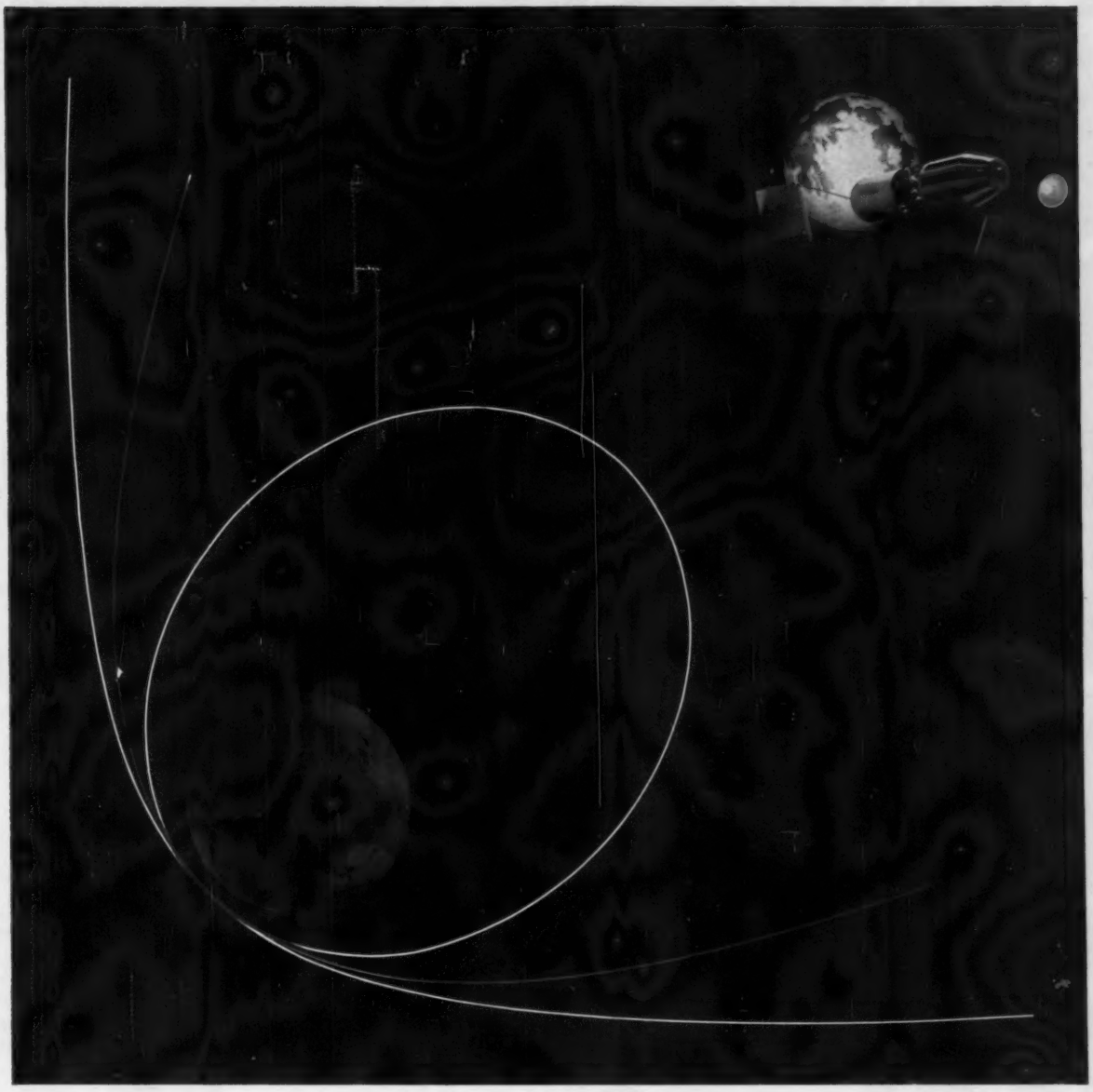

Orbits through space

The space-flight paths diagrammed above represent a closed elliptical orbit, a parabolic orbit, and, on the outside, an open, hyperbolic orbit characteristic of the start of an interplanetary flight.

Orbital flight mechanics is one of the many areas of advanced investigation at Boeing. The staff of the Boeing Scientific Research Laboratories, for example, carries out basic research in such fields as energy conversion, hypersonics, magneto-hydrodynamics and plasma physics.

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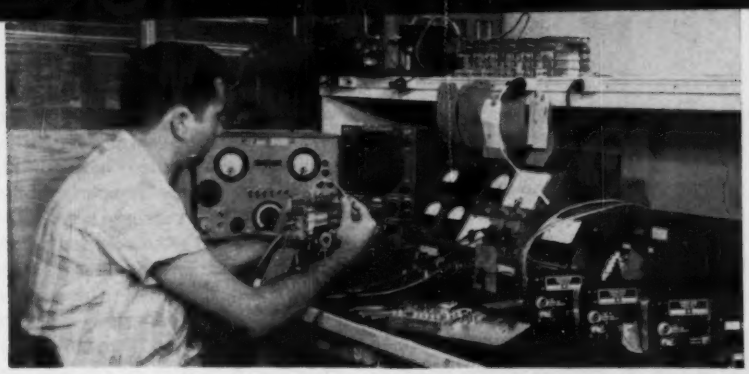


Technician in photograph above checks performance and alignment of the receivers, while the ladies on the right do their best to keep him busy

WIDEBAND F-M RECEIVER

FOR REMOTE AIRCRAFT CONTROL

By T. L. FISCHER, Senior Development Engineer, Babcock Radio Engineering Inc., Costa Mesa, Calif.

Receiver can provide a control link between ground station and a missile or missile-target airplane, it can control the flight path of a helicopter, or destroy a missile should it go dangerously off course. It is completely transistorized

THIS COMPLETELY TRANSISTORIZED 406 through 549-Mc f-m receiver has been designed to equal or exceed in performance, cost and producibility its vacuum-tube counterpart. Receivers of this type are widely used by the military as part of the radio link for remote control of missiles and missile-target aircraft. They are also used as range safety receivers for remotely terminating the flight of a vehicle should it go out of control.

This receiver is a self-contained unit providing a demodulated audio output for coupling to a variety of decoding equipment.

Command information is transmitted from a control point to the airborne receiver by a frequency-modulated carrier generated by a transmitter. Transmitter power output capabilities range from 30 to 1,000 watts. The transmitter is frequency modulated by as many as 20 tone channels dispersed approximately 12.5 percent apart from 7.5 to 73 Kc. These tone channels may be turned on an off, varied in amplitude, frequency modulated, pulsed on and off at a constant rate with varying pulse widths or used in other ways to convey command information. The deviation utilized is normally ± 300 Kc or ± 120 Kc; the latter being preferred for new designs.

Associated with the receiver in the aircraft are decoding, autopilot and electromechanical devices for

transforming electrical signals into the aircraft or missile response.

Visual or radar contact is maintained with the controlled aircraft and information regarding the flight path is made available to the controller operator. By a control system of this type, the difficult and complicated function of controlling the flight path of a helicopter is even possible.

Where danger exists from a missile or other unmanned aircraft that may leave its intended flight path and present a hazard, a range safety system is included. This same radio link can remotely terminate the uncontrolled flight—relay operation of the decoder energizes an explosive charge that may completely disintegrate the vehicle or separate a critical portion to abort its flight ability.

In all of the applications, reliability is of primary importance.

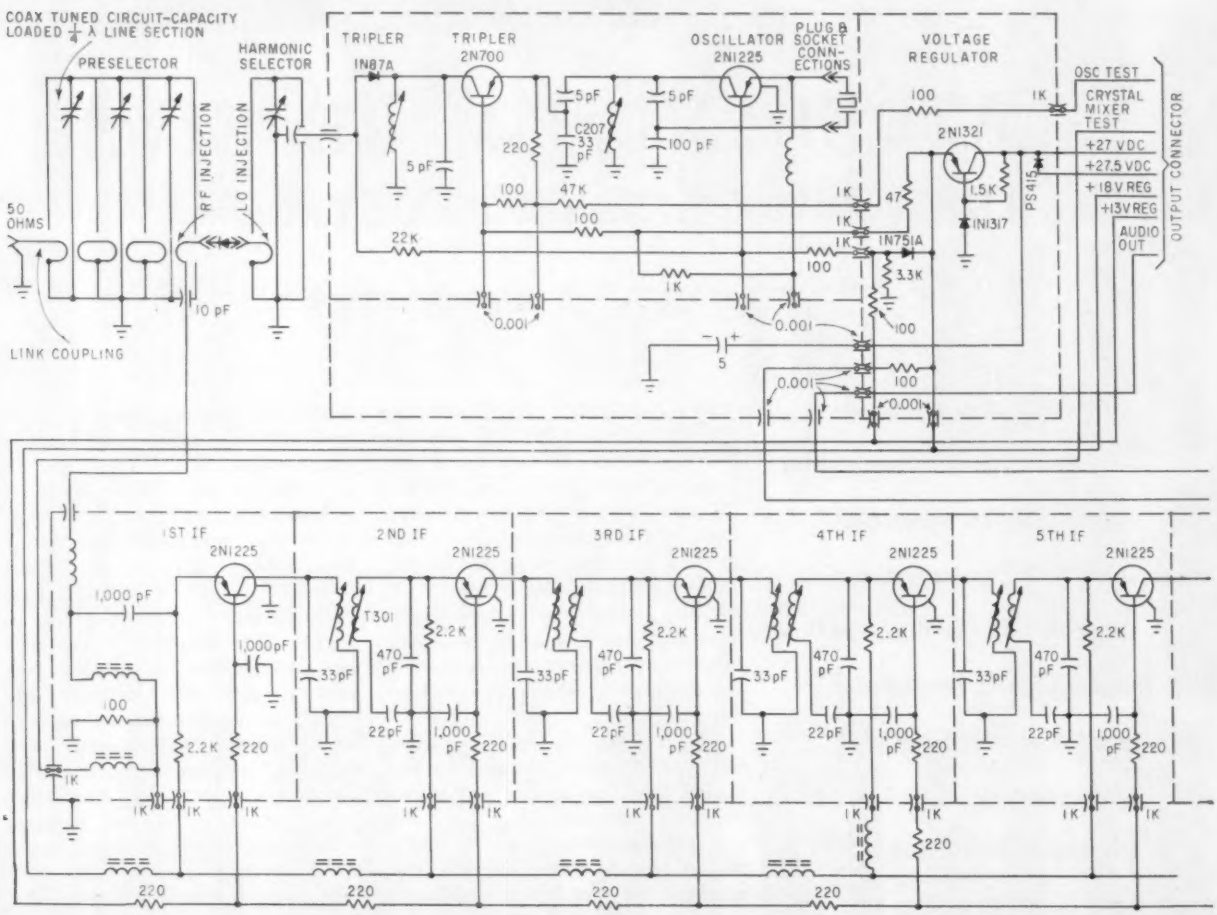
The receiver may be broken down into five separate sections as illustrated in the circuit diagram.

The preselector is composed of three identical sections of capacitance-tuned $\frac{1}{4}$ wave line. These sections are synchronously tuned and loaded to provide a flat, coupled bandpass of approximately 2 Mc. Under such conditions an overall insertion loss of as little as 1 db has been measured. The vswr at the input terminals is better than 1.5 to 1 over the 2-Mc bandwith. Three sections are necessary to reject the local oscillator energy in the third section and to prevent its passage to the antenna terminals. The three sections also provide image and spurious response rejection of greater than 60 db. The rejection requirements, together with the necessary operating Q, dictate the intermediate frequency which was chosen to be 33.5 Mc. The preselector operating Q is established by the allowable insertion loss with a given unloaded Q.

The low noise IN82A silicon mixer diode, which may be considered a part of the preselector, was chosen for its uniform characteristics and universal availability.

Crystal controlled local oscillator energy with a frequency tolerance of 0.005 percent is required for mixing with the r-f input in the mixer diode. The number of crystals required to cover the band in one Mc increments has been reduced from 144 to 78 by providing high-side injection for channels between 406 and 473 Mc and low-side injection from 473 through 549 Mc. With this arrangement, local oscillator energy between 439.5 and 515.5 Mc must be generated.

Generation of this local oscillator energy is accomplished in two transistors and one harmonic generating crystal diode. One of these, a 2N1225 drift transistor, is utilized in a common-base configuration with a third overtone type CR-52/U crystal to provide crystal controlled energy between approximately 48 and 58 Mc. This oscillator circuit is a modified Col-



pitts type with feedback between the collector and emitter circuits through the frequency determining quartz crystal.

The collector tuned circuit, which is resonant at the crystal frequency, has been provided with two capacitance taps. One tap allows optimum excitation for the crystal feedback circuit and the other provides impedance matching to the emitter of the tripler stage.

The tripler stage is a 2N700 mesa transistor connected in a common-base configuration. Maximum efficiency is obtained in this configuration with collector frequencies of approximately 146 through 171-8 Mc. Approximately 30 mw is required from this stage to drive the 1N87A harmonic generator crystal. The harmonic generator diode may be connected directly to the tripler collector because of the latter's relatively low impedance.

Selection of the third harmonic of the tripler stage or the ninth harmonic of the oscillator is accomplished in the high Q capacitance-loaded ¼ wavelength line section cavity. Operating Q of this circuit is made as high as practicable to reject the unwanted harmonics of the oscillator present in the tripler output circuit.

A link which provides injection into the mixer diode of the local-oscillator energy is inductively coupled to the harmonic selector.

The complete local oscillator is in a separate shielded compartment. All power leads entering this compartment are filtered by low inductance feed through capacitors. Local oscillator energy is confined to this compartment and cannot appear on the external power and control leads from which it may be radiated into other receiving equipment in the aircraft.

The receiver may be readily tuned to any frequency within its range by replacing the crystal and adjusting the preselector and local oscillator controls.

A transistor voltage regulator has been included in the receiver. Over the input voltage range of 22 to 32 volts, the maximum variation of output voltage is 5 percent.

The i-f amplifiers comprise eight stages, each of which uses a 2N1225 *pnp* drift transistor in the common-base configuration. The first four stages are double-tuned, the following three are single-tuned and the last one is the f-m detector driver.

Since the input impedance of the amplifier is approximately equal to the output impedance of the mixer over the passband of the amplifier, the mixer output is fed directly into the emitter of the first amplifier stage without a matching transformer.

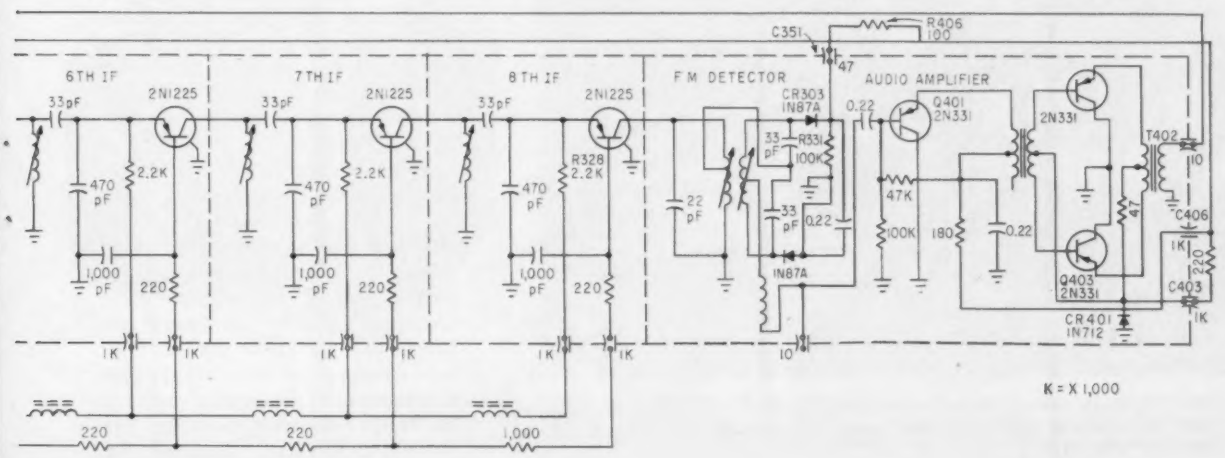
The power gain of each of the double-tuned i-f stages is 15 db. The following three single-tuned stages have a power gain of 20 db. each. The f-m demodulator is a modified ratio detector which provides maximum a-m rejection.

The audio information recovered from the detector is fed to a two-stage, transformer coupled amplifier. The input stage is a 2N331 *pnp* emitter follower which provides high input impedance (approximately 20K ohms) for minimum loading of the detector. The emitter output is coupled, by an impedance matching transformer, to the bases of a push-pull common-collector output stage using two 2N331 *pnp* transistors. The output transformer may be changed to provide various output impedances at a power level of approximately 40 m-w. Common-collector stages were used because of their inherent temperature stability and low output impedances. These low impedance circuits allow use of miniature transformers. The amplifier has a power gain of 38 db and a frequency response flat within 3 db from 5 Kc to 80 Kc.

The receiver section has been used in a missile command destruct unit by combining a transistorized decoder together with the receiver to form a completely transistorized range safety receiver. The decoder section of this unit has a logic circuit that prevents undesired operation of the destruct system by an interfering signal.

The author wishes to acknowledge the assistance of Claudio Silva during the development of this receiver and in the preparation of the article.

Every receiver stage is screened from its neighbors by the egg-crate construction of the chassis, which cuts down both electromagnetic and electrostatic strays. The eight i-f stages contribute to the overall gain of 100 db of the i-f strip, while their interstage transformers have specially shielded construction of powdered iron tube installed in a drawn-brass can. Local oscillator frequency is stable to within 0.005 percent, with frequency being changed by plugging-in fresh crystals



STAR TRACKER USES

Experimental stellar tracking system scans the image tube electronically, generating an error signal when the optical axis of the tracker deviates from the line of sight to the star. Tracking is at a rate of almost one radian per second

By WILLIAM D. ATWILL, Astrionics Laboratory, ITT Laboratories, Fort Wayne, Indiana

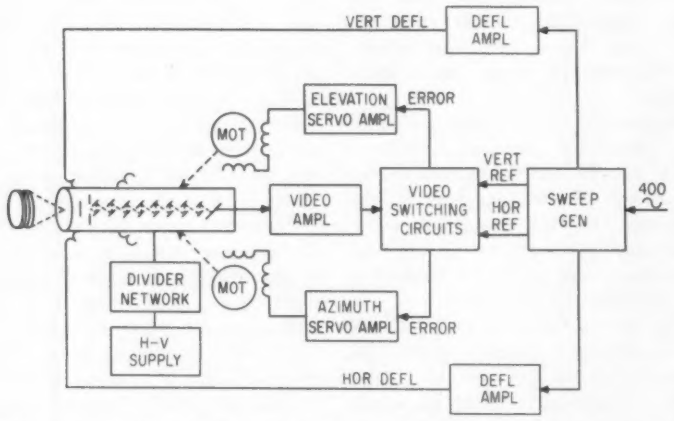


FIG. 1—Block diagram of star tracker shows how the azimuth and elevation servo motors are actuated to align the image tube with a star

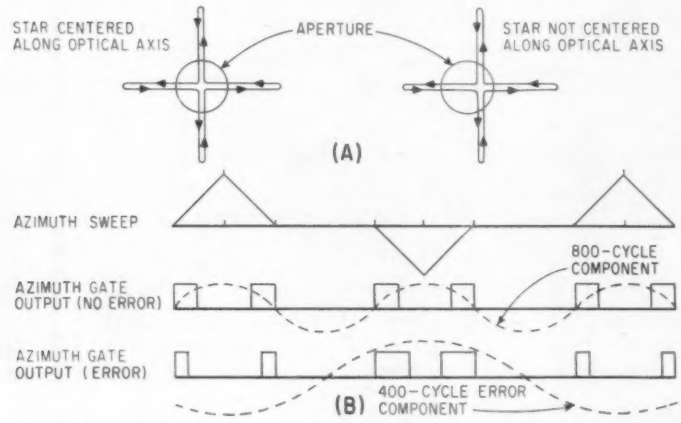


FIG. 2—Scan pattern across mechanical aperture (A) shows the centered and not-centered conditions that cause the azimuth gate outputs (B) of no-error and error

HIGH-SPEED ROTATING DEVICES in satellites and space vehicles present serious problems. Conventional bearings cannot be used in a vacuum because the lubricant will quickly evaporate. When precise control of vehicle attitude is required, the intermittent use of rotating devices would require removal of the angular momentum imparted to the vehicle. This requires the expenditure of additional energy by the vehicle attitude control system.

Conventional star trackers use a motor-driven reticle that modulates the star radiation prior to detection by a phototube. This requires either gimbaling the phototube, motor and optical system or the use of mirrors or prisms to direct the radiant energy to a stationary phototube. The vibration imparted to the tracking element by the scanning motor may limit the angular resolution of the tracker. These problems have prompted the design and development of an electronic scanning star tracker at ITT laboratories.

The tracking telescope is a compact unit including phototube, optical system and modulator. The telescope may be gimbaled to track from a stabilized base or may be fixed directly to the vehicle. Electronic scanning of the image section of the ITTL 6836 (or FW-118) tube generates an error signal that determines if the optical axis of the tracker deviates from the line of sight to the star. The scanning

ELECTRONIC SCANNING

technique was originally proposed by J. R. Clark, also of ITT laboratories.

An experimental stellar tracking system has been developed by the author that uses electronic scanning of the 6836 tube. The device has provided quantitative data on angular resolution and sensitivity. The tracker has operated continuously through nine 12-hour periods at scientific exhibits where tracking was demonstrated by using a series of lights that were operated sequentially to simulate a moving target.

The tracking head is shown in the photograph. This unit comprises the telescope, gimbals, and azimuth and elevation drive motors. The telescope contains a 1-inch achromatic objective with a 2-inch focal length preceding the multiplier image photo-tube. The rear section of the telescope contains the multiplier voltage divider and video coupling components. For exhibition all electronic circuits are remotely located and cable-connected to the tracking head.

A star image is focused on the photocathode of the 6836 by the telescope optics, as shown in Fig. 1. The 6836 tube is an image tube combined with a 16-stage multiplier section, with the screen of the image tube replaced by a small aperture. The photocathode converts the optical image to an electron image which is accelerated electrostatically through the aperture to the first dynode of the multiplier. The photocathode current is amplified 10,000,000 times in the multiplier section of the tube. Deflection coils sweep the electron image across the aperture in any desired sweep pattern. The output developed across the collector load impedance is a series of square waves. When the star image does not lie along the optical reference axis of the image tube, the time asymmetry of the square waves gives rise to a component at the fundamental sweep frequency. This component constitutes the error signal which when amplified drives the telescope servo motors. Synchronous gating circuits switch the output of the phototube alternately to the azimuth and elevation servo loops.

The sweep pattern used in the tracker is shown in Fig. 2A where the excursions of the beam are intentionally separated to show the continuous path involved. The square waves developed at the phototube collector have a duration determined by the time the electron image falls within the aperture. The switching circuits are synchronized to switch the tube output from one servo channel to the other each time the sweep returns the electron image to the center of the pattern. When a target appears in the field of view, each channel receives pairs of pulses separated by periods in which the opposite

Side view of tracking head (left) shows rear section of telescope, which contains the multiplier voltage divider and video coupling components. Author performs angular resolution measurements in laboratory setup (right). The electronics unit at left is cable-connected to the tracking head at center, which permits remote operation of the equipment

channel is completing one arm of the sweep pattern, as shown in Fig. 2B (middle). Since the sweep frequency is 400 cycles with 90 deg phase separation between channels, the four pulses per sweep received by each channel are the second harmonic, or 800 cycles. In Fig. 2A the sweep pattern is also shown for a star image displaced to the right. It can be seen that the pair of pulses for the right-hand portion of the azimuth sweep will have shorter durations than those from the left-hand portion. This gives rise to a fundamental component at 400 cycles which becomes the servo loop error signal as shown in Fig. 2B (bottom). The elevation error signal is developed in the same manner.

The deflection coils are driven by a near-triangular current waveform which is derived from a 400-cycle reference voltage as shown in Fig. 3A. Two sine waves with 90 deg phase separation are applied to two clamping circuits which pass only the peaks of the waves and clamp them to zero. This technique provides a waveform with two triangular-shaped portions separated by a zero period of slightly more than 90 deg (Fig. 2B top). During this zero period the other channel executes the sweep of one arm of the sweep pattern. The sweep signals are amplified and applied to the deflection driver stages which have the deflection coils as cathode loads.

Video switching circuits permit the video signals to go to the proper servo loop. To accomplish this, the 400-cycle sweep reference voltage is full-wave rectified. The 800-cycle pulsating d-c is capacitively coupled to a paraphase amplifier. The outputs of this amplifier are alternate positive and negative control pulses for each arm of the sweep pattern.

The control pulses are directed to the gate driver stages which open and close the azimuth and elevation gates, as in Fig. 3B. These gates allow the output of the video amplifier to be applied alternately to the elevation and azimuth servo loops.

The design of the stellar tracker circuits is such that there is an 800-cycle signal present whenever a star is within the field of view. This signal may be used to indicate that the system is tracking even though the 400-cycle error signal has been nulled by the servo drive.

The 800-cps carrier is removed from the azimuth and elevation signals by low-pass filters. The remaining 400-cps error signals are applied to audio power amplifiers. The power amplifiers drive the control phase windings of the two-phase 400-cps servo motors. A phase-shift capacitor is connected in series with the fixed phase winding of the elevation motor and the 400-cps supply. The azimuth motor phase shift is accomplished in the deflection circuit.

The elevation motor has a stall torque of 1.33 oz-in. and drives the telescope through a 200-to-1 precision gear train. The azimuth motor has a stall torque of 2.35 oz-in., driving the telescope through a 100:1 precision gear box.

Experiments with the dynamic response of the tracker have shown that it is capable of tracking at a rate of almost one radian a second.

The image section of the 6836 phototube consists of a photocathode 0.75 inch in diameter that is electrically connected to one element of an electrostatic lens. The other element of the lens contains the mechanical aperture and is at the same potential as the first dynode of the multiplier section. The action of the lens is to project the mechanical aperture on to the photocathode. This results in a small active area at the photocathode. The trajectories of photoelectrons resulting from incident light outside this active area do not pass through the aperture. In the present design, the magnification of the image section of the 6836 (FW-118) tube is 0.7. The tube has a 0.07-inch aperture giving a 0.1-inch diameter active area on the photocathode. With no external deflection field applied, this active area is in the center of the photocathode and aligned with the longitudinal axis of the tube.

The area of the photocathode used in scanning may be visualized by assuming the projection of the mechanical aperture being moved about the photocathode in the sweep pattern. If radiant energy falls within this area, the photoelectrons will be swept across the aperture in the sweep pattern.

In describing the tracking operation there are two important terms scan field of view and instantaneous field of view. The scan field refers to the solid angle projecting from the telescope objective in which the presence of a radiant source will result in an electronic signal from the phototube. The size of this angle depends on the amplitude of the deflection circuits and the telescope optics. In the experimental model the deflection amplitude is such that the active area is extended to two-thirds of the diameter of the photocathode in the cross sweep pattern. Combining the diameter of the photocathode and the 2-inch focal length of the optics gives a scan field of view of 15 deg. This large scan field of view was necessary to allow acquisition of successive lights in the demonstration of the tracker. In true star tracking a much smaller scan field of view would be required to prevent locking on stars with a small angular separation from the target star. To generate a usable electronic signal it is necessary only to deflect the electron star image through three times the diameter of the basic 0.1-inch active area. With the proper optics the scan field could be reduced to five deg or less.

The instantaneous field of view refers to the solid angle projecting from the telescope determined by the focal length of the optics and the small active area of the photocathode at any instant of the sweep excursions, this area being the projection of the mechanical aperture on the photocathode. This 0.1-inch diameter area and the 2-inch focal length objective of the experimental model yields an instantaneous field of view of 2.86 deg.

The image of a star when focused on the photocathode is small compared to the 0.1-inch diameter active area. The phototube and electronics are capable of resolving the position of the image to one-half percent of the active area that is equivalent to one-half percent of the instantaneous field of view. This is the means of determining the basic pointing accuracy of the stellar tracker. For the experimental model the theoretical pointing error would be less than a minute of arc.

A laboratory facility has been devised for determining the accuracy of the stellar tracker. The arrangement for measuring angular resolution is shown in the photograph. A simulated star is formed by directing a collimated light source on a mask in which a one-mil aperture is mounted. The light source intensity is controlled to simulate stars of various magnitudes. The assembly is mounted on a precision mechanical stage. The simulated star may be moved perpendicularly to the line of sight to the tracking head with a linear resolution of 0.001 inch. At the separation shown, star angular motion on the order of six seconds of arc may be produced. The resulting azimuth rotation of the stellar tracker is measured by another optical system. A prism is mounted vertically on the azimuth gimbal of the tracking head and a reticle is projected on the prism by another light source. The reticle image is reflected to an accurate scale where the motion of the tracker is detected. An angular resolution in azimuth of approximately one-half minute of arc has been measured.

The most important consideration in improving the stellar tracker design is the use of miniature transistor circuits. The functions of sweep generation, video amplification and switching could be accomplished by transistor circuits occupying a volume of 10 cubic inches and weighing about 12 ounces. It is possible to design the tracker so that all of the electronics including high voltage supply (excluding servo amplifier) could be housed in a cylindrical package slightly smaller than the telescope of the experimental model. The unit could be fastened rigidly to a vehicle and the error signals applied to the attitude control system. The error signal could also be amplified and used to drive the telescope to null as in the experimental model. The basic package would require only a total of five watts of d-c and 400-cps power.

The use of magnetic deflection is well suited to low-impedance transistor drive circuits. The sweep waveforms do not involve abrupt current changes, alleviating the high reactive voltages attendant to flyback circuits.

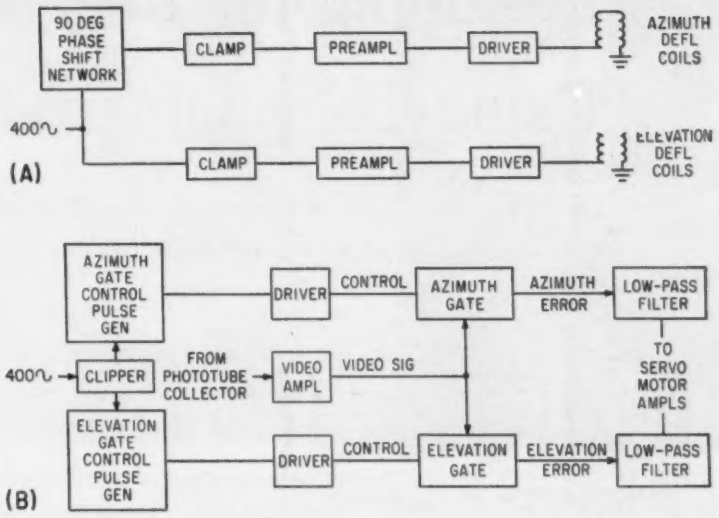


FIG. 3—Block diagrams of deflection circuits (A) that apply triangular waves to the deflection coils, and of switching circuits (B) that control correction signals to the servo motors

Voltage divider current for the multiplier phototube section is only 0.8 ma at 1,600 volts. Tube current is a fraction of this amount. The present high voltage supply is a full-wave voltage doubler using silicon diodes. This supply could easily be miniaturized to occupy no more space than that now occupied by the voltage divider in the pill-box structure at the rear of the experimental telescope.

The electronic circuits may be extended forward of the phototube to surround the volume between the objective lens and the photocathode and provide a small lens shade in front of the objective.

Several refinements in the design of the phototube will contribute to increased accuracy as well as ease of packaging. The latest model of the phototube (FW-118) is smaller than previous designs and uses a deposited aluminum film in place of the first metal cylinder of the electrostatic lens. In the old design the magnetic flux from the deflection yoke had to penetrate a comparatively thick metal cylinder. Eddy currents set up in the cylinder caused bending of the magnetic lines with the resulting degradation of the sweep pattern.

In deflection the electron image of the target is swept across the mechanical aperture of the tube. It is desired to create an on-off switching action as the beam passes over the edge of the aperture. The finite size of the electron image makes the generation of true square waves impossible. Certain improvements in the design of the image section of the tube will improve the signal-generating characteristics.

For this particular application, the multiplier voltage divider network may be contained within the envelope of the tube. Glass sealed resistors may be connected between the 16 dynodes of the multiplier, reducing the number of base pins from 19 to 3. This allows the use of a 1½-inch outside diameter for the main body of the tube. This modification has already been made with success on a 6836 tube.

The use of electrostatic deflection of the phototube is being investigated, but the increased mechanical complexity involved in electrostatic deflection may offset the saving in weight and space by the absence of deflection coils.

The potential difference across the electrostatic lens is about 200 volts. The electrons passing through the field do not acquire much kinetic energy, thus they are easily deflected. This requires a small magnetic flux to deflect the beam sufficiently.

Designing for Reliability Using Thermal Analog Tubes

Device simulating size and thermal characteristics of vacuum tube is used to evaluate tube performance under various environmental conditions

By M. F. SILVERSTEIN,
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INCREASING DEMAND for electronic equipment that achieves high reliability has been met by improved tools and techniques. Since many equipment failures can be attributed to the electron tube, considerable effort has been expended on improving tube performance.

Heat is a major cause of electron tube failures. Operation beyond the maximum electrical or thermal ratings usually results in a reduction in electron-tube reliability.

The Thermion, a thermal analog of a vacuum tube, is a valuable aid to the design engineer in the performance of electron tube thermal evaluation. Externally, it is physically identical to a vacuum tube of the same size class. Internally, the thermal structure of the thermal-analog tube simulates that of a conventional tube. This result is attained by a heating element surrounded by an anode.

In any electron tube the anode usually surrounds the cathode; thus, the cathode reaches thermal equilibrium by radiation to the bulb and environment. Therefore, the anode is an index of the thermal condition of a tube.

Measurement of anode temperature must be accurate owing to the effective change in environment for small changes in radiation loss. This measurement is performed by a thermocouple attached to the anode. Bulb temperature measurement is obtained by fusing a thermocouple to the inside of the bulb where it poses no problem to tight-fitting tube shields.

To show the use of the thermal analog in electron tube thermal studies, a series of experiments have been established. The setup is shown in the photo.

Prediction of environmental effects on the thermal performance of electron tubes is complex. This is shown by subjecting a T7L5 thermal analog tube to an immediate environment of dry ice, which maintains a temperature of approximately −40 C while varying the reflectivity of the environment with tube shields (see photo). Data is given in Table I.

An analysis reveals that although the bulb was cooled to a subzero temperature, the plate was cooled slightly since conduction cooling of the plate was offset by an apparent decrease in plate emissivity caused by reflection of the radiant energy by the ice.

The heat-dissipating tube shield, when surrounded by dry ice, does not cool the bulb as much as in the bare tube; however, an increase in plate cooling was noted since this shield has a blackened inner surface that absorbs radiant energy. Also, the heat dissipating tube shield cools the bulb well below the critical temperature so that further cooling will not enhance the reliability of the tube. The point of diminishing returns for bulb cooling is at a much higher bulb temperature.

Although cooled to a subzero temperature, the shiny JAN shield not only increases the bulb temperature slightly over that of the bare tube, but also increases the plate temperature. Accordingly, thermal conditions arise indicating the need to determine which shield possesses the best absorption of radiant energy in a given environment.

Since it is not subject to the mechanical and electrical limitations on instrumented electron

Table I—Effect of Dry Ice Environment on Tube's Thermal Performace

Environmental Conditions[a]	Plate Temp (deg C)	Bulb Temp (deg C)
Bare tube at room ambient	440	170
Bare tube packed in dry ice	432	below zero
With heat dissipating tube shield packed in dry ice	428	20
With shiny JAN shield packed in dry ice	455	176

(a) Thermion power input—15 watts

Table II—Effect of Immersion in Water on Tube's Thermal Performance

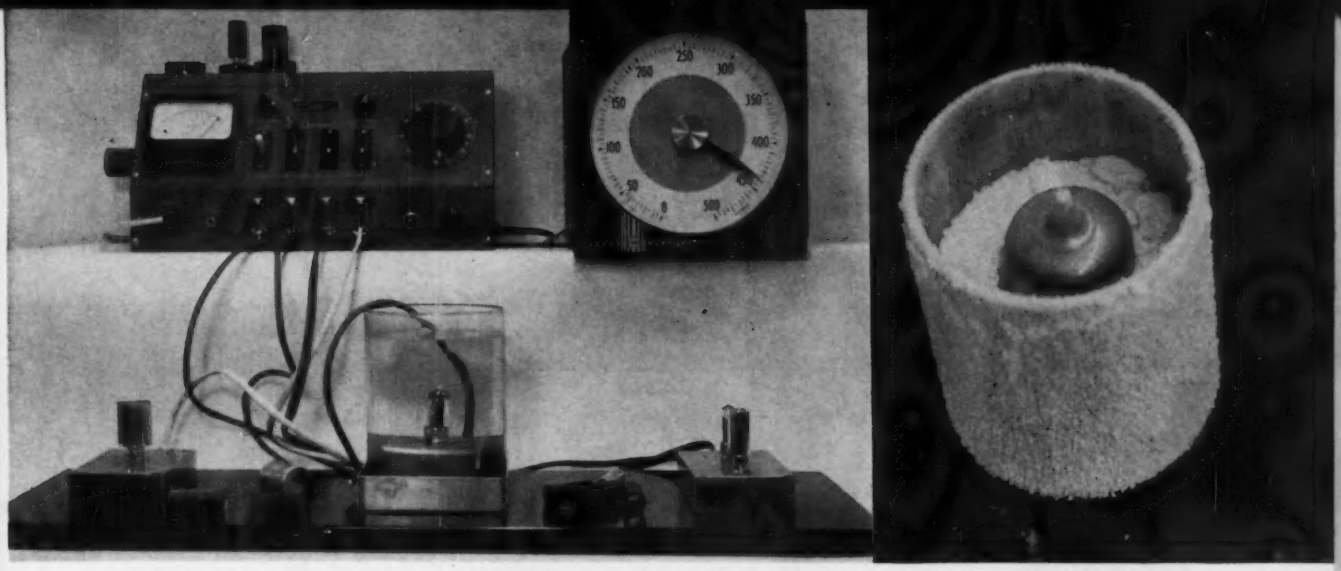
Environmental Conditions[a]	Plate Temp (deg C)	Bulb Temp (deg C)
Bare tube at room temperature	438	180
Bare tube submerged in room temperature water	423	30
With heat dissipating tube shield submerged in water	425	34
Shiny JAN shield submerged in water	426	45

(a) Thermion power input—15 watts

Table III—Effect of Shielding on Tube's Thermal Performance

	Tube B		Tube C	
Conditions [a,b]	Plate Temp (deg C)	Bulb Temp (deg C)	Plate Temp (deg C)	Bulb Temp (deg C)
Tubes B & C powered—bare tube[c]	435	180	436	180
Tubes A, B & C powered—bare tube	437	203	440	185
Tube shields on B & C—no shield on A	433	175	440	164
JAN shields on B & C—no shield on A	465	280	455	265

(a) Thermion power input—15 watts (b) All measurements at room ambient (c) See figure for tube positions



Experimental setup (above) for determining thermal characteristics of thermal-analog tube surrounded by JAN type shield (left), immersed in water (center), three operating tubes mounted in close proximity on chassis (right). Second photo shows tube packed in dry ice to maintain temperature of —40 C

tubes, the thermal analog may be used to evaluate virtually any type of cooling media. The data in Table II is representative of a T7L5 tube immersed in water. No precautions were taken to pot or moisture-proof the electrical connections to the tube.

Analysis reveals that the reflectivity of the material surrounding the tube does not affect the plate and bulb temperatures to the degree that is experienced with extreme cooling of the material itself. This characteristic is shown by the minor deviations in plate temperature between the bare tube and tube shield conditions; even the shiny JAN shield does not increase the bulb temperature significantly with this cooling medium. Since water absorbs most of the radiant energy transmitted by the glass, little energy is reflected even with a highly reflective material; thus, the JAN shield has little effect on tube temperature.

Heat dissipating tube shields are especially effective in reducing the bulb hot spot temperature. Efficient use of tube shields, however, can only be realized if environmental conditions are considered. For instance, at elevated environmental temperatures certain shields exhibit a lesser degree of cooling than in the bare tube case, whereas the opposite is true at room temperature.

The thermal analog provides a convenient means for evaluating tube shields in an operational environment. Three T7L5 tubes were mounted on a chassis as indicated in the figure. The results are given in Table III.

With tubes *A*, *B* and *C* powered for the bare tube condition, a hot spot is generated on tube *B* owing to the proximity of tube *A*. This reaction is determined by comparison of the measurements on tubes *B* and *C* powered for the bare tube. The beneficial effect of a heat dissipating tube shield is indicated by comparing the bare tube with tubes *A*, *B*, and *C*.

Notice the reduction in hot spot temperature of tube *B*. The deleterious effects of the shiny JAN shield are evident. Using this technique, tube location and spacing can be investigated for hot spots and shielding under various environmental conditions.

Development of silicone rubber compounds for insulating electron tubes has proved an efficient means of reducing shock and vibration effects. Since the heat conductivity of silicone rubber is reduced this material must be used judiciously for electron-tube applications. The thermal analog can help determine electron-tube thermal efficiency where a potting compound is used.

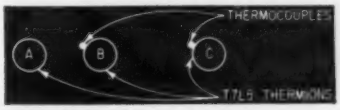
A typical evaluation of a silicone rubber compound was performed by molding a T7L5 with one of the compounds. Results are given in Table IV.

Room-temperature molded-tube measurements show that natural convection is an unsatisfactory cooling medium. They suggest that cooling may be obtained by forced convection. If the application is such that the use of extensive cooling equipment is not possible, the tube must be derated.

Table IV—Effect of Silicone Rubber Compound on Tube's Thermal Performance

Environmental Conditions[a]	Anode Temp (deg C)	Bulb Temp (deg C)
Bare tube at room ambient	430	180
Molded tube at room ambient	452	224
Molded tube submerged in room temperature water	438	78
Molded tube forced air cooling	445	126

(a) Thermion power input—15 watts



Physical arrangement of thermal-analog tube and thermocouples for evaluating tube shield in operational environment

Feedback Circuits for A-C

By EVERETT A. GILBERT,
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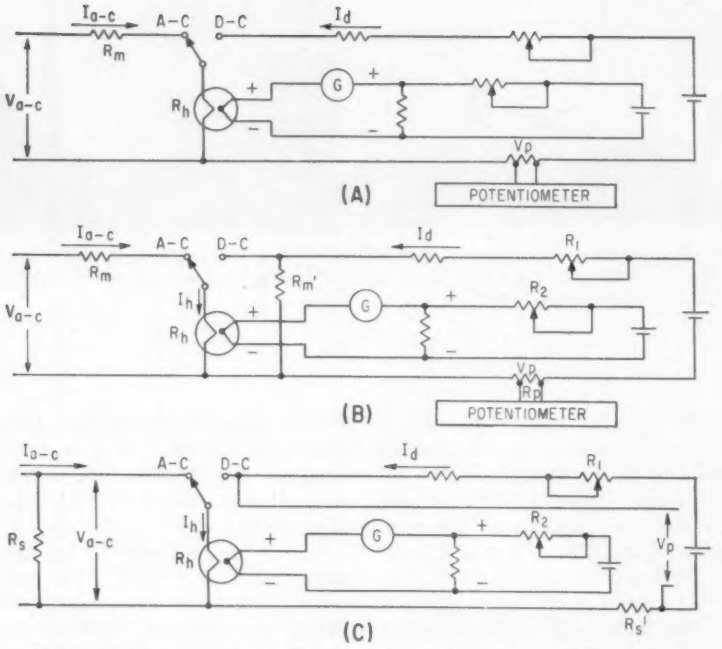


FIG. 1—Simple a-c to d-c thermocouple transfer circuit for voltage measurements (A) is made insensitive to changes in thermocouple heater resistance in (B). Compensated current transfer circuit is shown in (C)

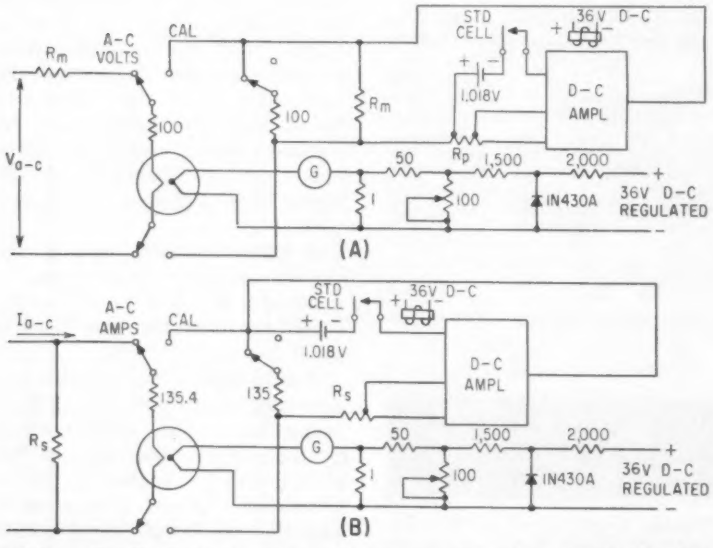


FIG. 2—Feedback circuit can be used for a-c to d-c voltage standardization (A) and a-c to d-c current standardization (B)

AS ELECTRICAL INSTRUMENTS become more sophisticated and accurate, greater accuracies are required in the standardizing equipment to test and calibrate these instruments. Expanded scale voltmeters, a-c digital voltmeters and high-grade a-c instruments may require standardizing accuracies of ±0.05 percent over frequency ranges of 50 to 2,000 cycles.

One method of standardizing a-c currents to accuracies of 0.01 to 0.02 percent is with a thermocouple transfer arrangement in which a-c currents are measured with a vacuum thermocouple in terms of the d-c current necessary to create the same thermocouple output as the a-c current. This means the thermocouple is switched from the a-c circuit into a d-c circuit in which the current can be measured accurately using d-c potentiometers and standard cells.

Figure 1A shows a simple thermocouple transfer circuit for voltage measurements. Figure 1B shows the thermocouple transfer circuit used by the National Bureau of Standards[1]. The latter circuit has an advantage over the first in that variations in thermocouple resistance are compensated for by the resistor R_m'. This compensation effect occurs as follows. With the transfer switch to the a-c side, $V_{a-c} = I_{a-c}\ (R_m + R_h)$. With the thermocouple switch to the d-c side, $I_h = I_d\,[R_m'/(R_h + R_m')] = (V_p/R_p)\,[R_m'/(R_h + R_m')]$. By adjusting $I_h = I_{a-c}$ using the thermocouple, and since $R_m = R_m'$, $V_{a-c} = V_p\ R_m/R_p$. Thus, the resistance of the thermocouple heater is eliminated from the equation.

Figure 1C shows a compensated current transfer circuit. With the

Instrument Calibration

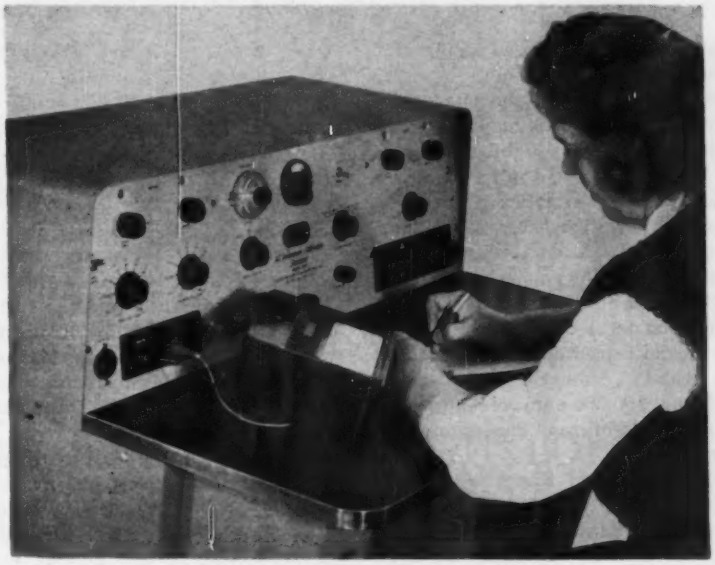
High-gain d-c amplifier is used in a feedback circuit to standardize a-c currents and voltages directly to a standard cell. Circuit establishes a thermocouple calibrating current that is directly proportional to standard cell voltage to an accuracy of ±0.01 percent

thermocouple connected across the shunt, R_s, the current through the heater is $I_h = I_{a-c} R_s/(R_h + R_s)$. With the switch to the d-c side, $V_p = I_d (R_h + R_s')$. As $I_h = I_d$, $R_s' = R_s$ and at frequencies low enough so that the a-c and d-c resistance of the heater are equal, $I_{a-c} = V_p/R_s$, again independent of heater resistance. Referring back to Fig. 1B to show the general operation, the transfer switch is first positioned to the a-c side and the resistance R_2 adjusted so as to balance the galvanometer. The transfer switch is moved to the d-c side and resistance R_1 adjusted to bring the galvanometer to balance again. The voltage V_p across R_p is measured with the potentiometer and the a-c voltages obtained by the equation $V_{a-c} = (V_p/R_p)\ R_m$; R_m and R_p are selected to make the circuit direct reading in a-c voltage.

For standardizing a-c currents and voltages directly to a standard cell and at the same time eliminating the requirement for adjusting R_1, the circuits of Fig. 1B and 1C can be modified to the circuits shown in Fig. 2. These circuits include the standard cell and a high-gain d-c servo amplifier that automatically establishes thermocouple calibrating current directly proportional to standard cell voltage to an accuracy of ±0.01 percent. Assuming a gain stability of ±30 percent it is necessary to have a minimum open loop gain of 70 db.

The feedback stabilization of high-gain servo systems is accomplished through shaping of the open-loop frequency response[5]. Figure 3 shows a steady-state open-loop frequency response curve that will meet the usual requirements for instrument calibration. As 60 (ω = 377) and 120 cps are present due to the chopper and power supplies, these frequencies are attenuated more than 20 and 30 db below unity gain.

An entire frequency decade at 20 db per decade slope is allowed in the region of unity gain to ensure stability and good transient response. A slope of 60 db per decade is used over the initial attenuation ranges to keep the first break high in frequency and the closed-loop response time down. The transient



Calibration console for a-c meters uses thermocouple transfer standards. Voltmeters, ammeters and wattmeters can be calibrated to within 0.1 percent of reading

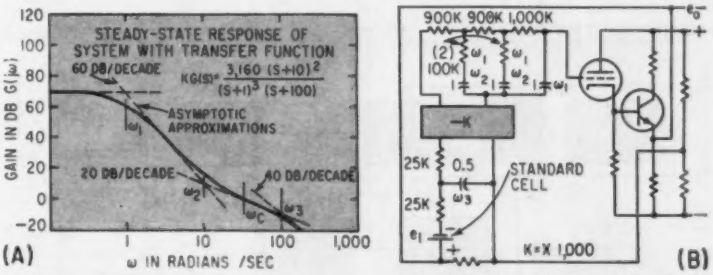


FIG. 3—Open-loop frequency response of feedback amplifier meets usual requirements for instrument calibration

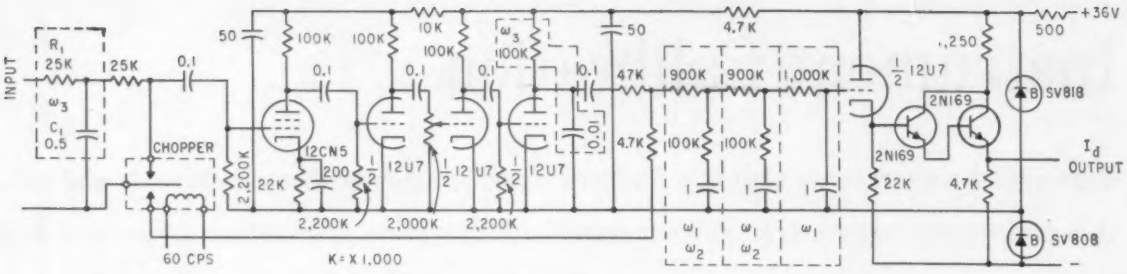


FIG. 4—Schematic of d-c feedback amplifier shows critical frequencies with their associated controlling components. Hybrid amplifier circuit supplies 7.5 milliamperes to the thermocouple

condition of the closed loop due to switching will die out in a few tenths of a second and allow accurate readings to be made after the thermocouple has stabilized.

Figure 4 shows the feedback amplifier with the critical frequencies marked near the controlling components. The ω_3 at the input is determined by the values of R_1 and C_1. The three tandem networks of 1 megohm total resistance and 1-microfarad capacitance are critical at ω_1; the two subnetworks consisting of the 100,000-ohm resistors and the 1-microfarad capacitors are critical at ω_2.

The circuit of Fig. 4 is a hybrid circuit using both tubes and transistors. A high-impedance grid input is required to realize the large time constants associated with ω_3. A low impedance is required at the output to supply 7.5 milliamperes to the thermocouple. This requirement is satisfied by *npn* transistors. The chopper amplifier was constructed with tubes to attain good temperature stability. Low plate voltage tube types were used in the amplifier so that the power supply would be compatible with both the vacuum-tube circuits and the transistor circuits. The tube filaments were supplied from the common regulated d-c supply to reduce hum pickup and improve the gain stability.

A method of using the circuits of Fig. 2 to calibrate electrical instruments is shown in Fig. 5. Variable-frequency power supplies with short time stabilities of 0.01 percent are standardized against the standard cell by the thermocouple transfer circuits. One of the power supplies is designed for constant voltage output and the other for constant current output.

Voltage ratio transformers with a wide frequency response and low leakage reactance set the output to the desired calibration voltage. Current ratio transformers provide the desired current output.

The photograph shows a complete console for calibrating a-c meters to 0.1 percent accuracy over the frequency range of 50 to 2,400 cps. An accuracy of 0.05 percent is attainable at 60 and 400 cps. The full-scale ranges of the a-c voltmeters may be between 1.5 millivolts and 1,500 volts. Ammeters with ranges between 15 microamperes and 75 amperes (a-c) may be calibrated.

For wattmeters, the two variable-frequency power supplies are locked together at unity phase angle. Each power amplifier is essentially a power oscillator with a fraction of the output fed back to the input through an L-C frequency controlling network and a thermal regulating bridge. When energy from the output of one of the variable-frequency power supplies is applied to the input of the other power supply, the frequency of the second locks to the first.

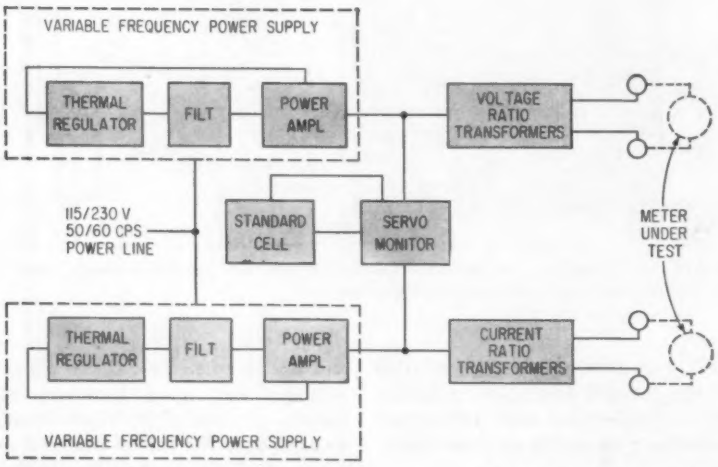


FIG. 5—Instrument calibration system uses servo a-c to d-c thermocouple transfer standards. Variable-frequency power supplies are locked together at unity phase angle when calibrating wattmeters

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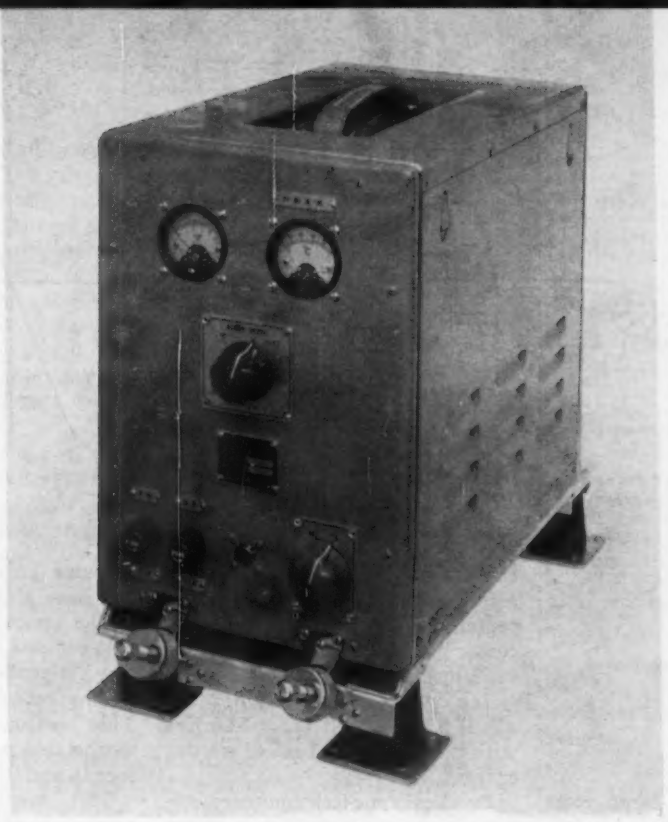

Fully transistorized sync signal generator includes sync lock circuit

Automatic Frequency Control With Reactance Transistors

Automatic frequency control is obtained in a transistorized tv remote sync lock circuit by controlling bias on reactance transistor. Capacitive and inductive circuits are shown

By YASUSHI FUJIMURA and NOBUO MII,
NHK Technical Research Laboratories, Japan Broadcasting Corp., Tokyo, Japan

TRANSISTORIZED REMOTE sync signal lock equipment is useful in field pickups and station relays. The fundamental circuit of the sync lock circuit that will be described here is an automatic frequency control circuit using a reactance transistor configuration.

A frequency modulated signal can be generated directly by controlling the d-c bias of a reactance transistor with a modulating voltage from an oscillator.[1] In the circuit diagram shown in Fig. 1, the tank circuit of the plate tuning oscillator transistor Q_1 is shunted by reactance transistor Q_2.

Here, the reactance transistor acts as a capacitance element and its equivalent capacitance C_{eq} is found from

$$C_{eq} = h_{21e} C_1 R_1 / h_{11e} \qquad (1)$$

where h_{11e}, is the input impedance (common emitter) with output short circuited and h_{21e} is the forward current transfer ratio (c e) with output short circuited. This relationship holds where operating frequency is lower than β cutoff frequency.

Therefore, the modulating voltage varies the expression h_{21e}/h_{11e} which has the same dimension as $1/g_m$ in electron tubes. As indicated in Eq. 1 this action varies the capac-

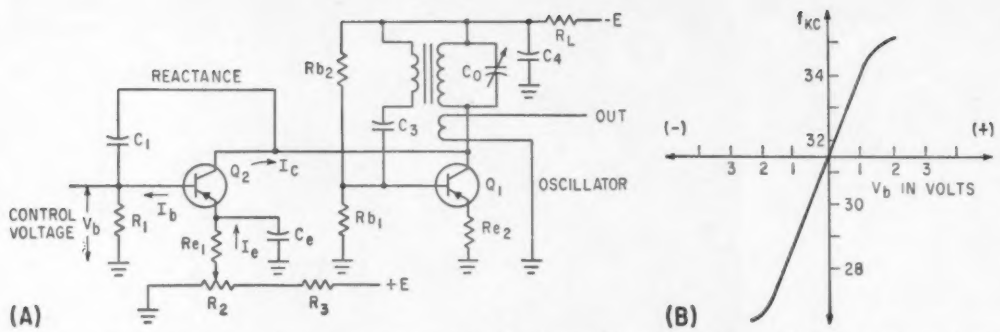

FIG. 1—Capacitive transistor in frequency modulation circuit (A). Dynamic sensitivity can be obtained from frequency deviation curve (B)

itance and hence the frequency.

The frequency modulation ratio $\Delta f/f$ is

$$\frac{\Delta f}{f} = \frac{C_1 R_1}{2C}\,\delta\,\frac{h_{21e}}{h_{11e}} \qquad (2)$$

where

$$C = C_e + C_{ag}$$

Since C_1 should be large compared with $1/h_{22e}$ (ordinarily 20,000 to 50,000 ohms), its value is 100 pf ($|Z|$ = 300,000 ohms at 31.5 Kc). Resistor R_1 should be smaller than $h_{11e} + h_{21e}R_{e1}$ and a value of 4,700 ohms is used to meet this need.

For these circuit valves given, the frequency deviation curve shown in Fig. 1B is obtained for a center frequency of 31.5 Kc and a center biased emitter current of 0.6 milliamperes.

The dynamic sensitivity $S = \Delta f/\Delta V_b$ is 2.5 Kc/1 volt (f_o = 31.5 Kc) with the bias set at 1 ma of emitter current.

Practical sync-lock equipment using a reactance transistor is shown in Fig. 2. The sync lock circuit is part of a fully transistorized sync signal generator. It is designed for higher stable sync lock against the noise interference on relay lines. These fully transistorized circuits consume only 0.7 watt of power and have high reliability.

The remote sync separation circuit consists of Q_9, Q_{10}, Q_{11} and Q_{12}. The horizontal sync pulse is formed at the collector of transistor Q_9. This horizontal sync triggers the monostable multivibrator (transistors Q_7 and Q_8).

This monostable multivibrator acts as a gate. It is designed to close the circuit during the intervals of horizontal pulses and against noise interference on the loop. Thus, the pure horizontal pulse (15.75 Kc) drives the discriminator, which consists of the bridge

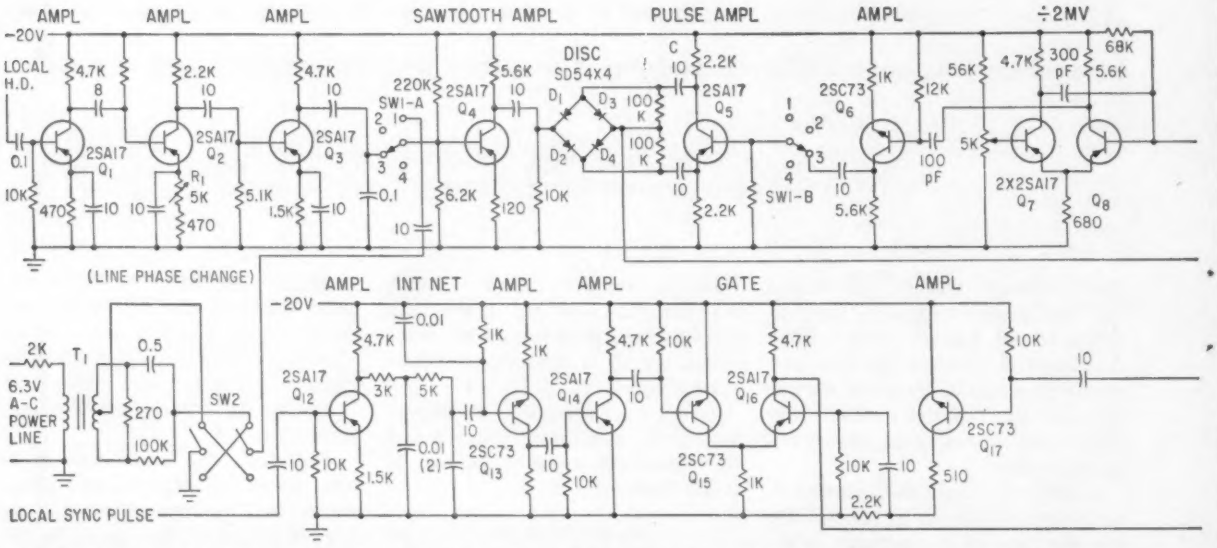

FIG. 2—Sync signal lock circuit shows how reactance transistor is used to provide automatic frequency control in this transis-

connection using four diodes (D_1 to D_4).

The local horizontal driving pulse switches Q_7 through the driver amplifiers Q_1 and Q_2, generating a sawtooth wave on the collector of Q_2. This sawtooth waveform is also fed to the discriminator.

The variable resistor R_1 adjusts the static phase difference, due to delay in the circuit, of both horizontal pulses while the afc is locked. Thus, the discriminator detects the phase difference between the remote horizontal sync and the local one, producing a d-c component proportional to phase difference.

This d-c component controls reactance transistor Q_{21} through a low-pass filter and then, by controlling the frequency of oscillator Q_{22}, the phase of local horizontal sync coincides with the remote horizontal sync.

To make the phase of the vertical pulses coincide, gate circuit Q_{15} and Q_{16} compares the remote and local vertical sync pulses that have been separated from each composite sync pulse. This yields a vertical correction pulse that acts to miscount the ÷ 525 counter of the sync-signal generator.

The reactance transistor also works to maintain a fixed phase relationship with the 60-cps primary power source when the switch is positioned at line lock.

This sync lock circuit is compact and ordinarily is contained in the sync signal generator. The locking stability against the variation of the ambient temperature is good. Virtually no change in output occurs from −10 C to +45 C and no adjustment is required over this range.

The automatic frequency control system maintains synchronism over a frequency range of ± 1.5 Kc (at the center frequency is 31.5 Kc). Its pull-in frequency range is ± 0.7 Kc.

Mislocking caused by noise interference is reduced from that obtained with tube circuits.

The capacitance transistor has been discussed here. However, the same concept can be applied to the inductance transistor as shown in Fig. 3.

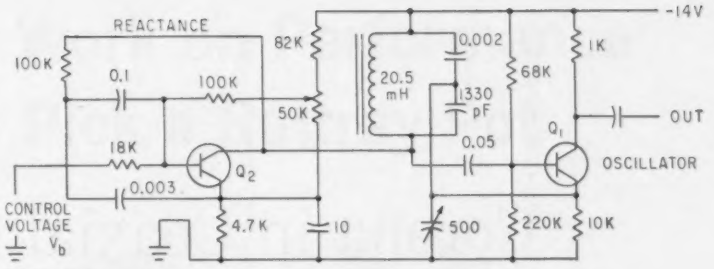

FIG. 3—Frequency modulation circuit using inductive transistor

A detail derivation of the equations for equivalent capacitance, equivalent induct and frequency deviation is presented in the reference cited.

The authors wish to acknowledge the contribution of the members of studio facilities section in NHK and Hitachi Ltd. to the work described here.

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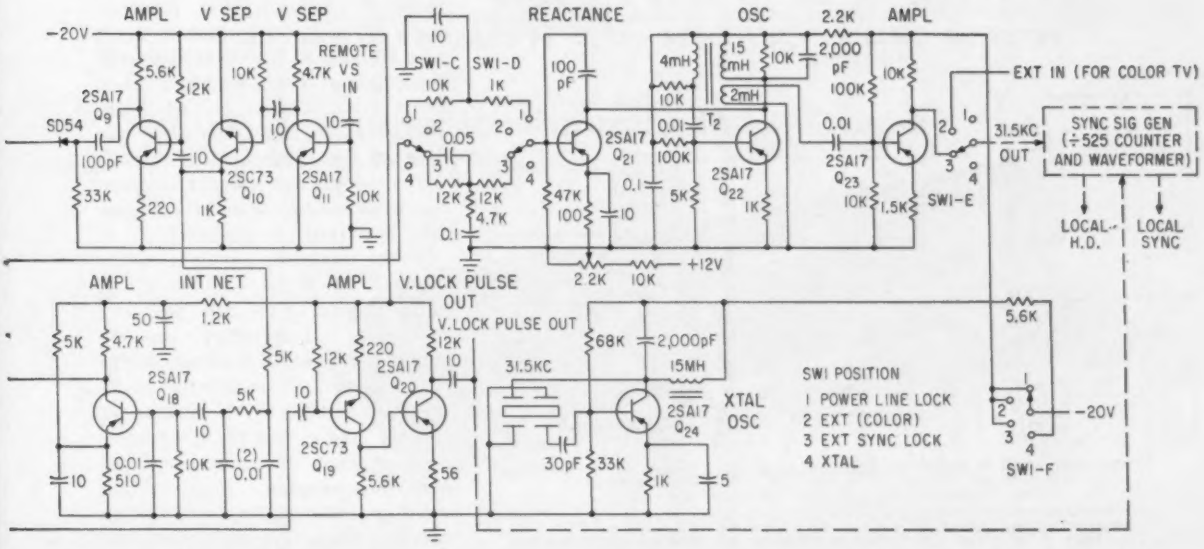

torized sync signal generator

Corona in Coaxial Cables

Preparation of cable specimens for corona testing, test circuits and calibration of equipment are discussed here as a guide to cable manufacturers

By JOHN P. AGRIOS, U. S. Army Signal Research & Development Laboratory, Fort Monmouth, N. J.

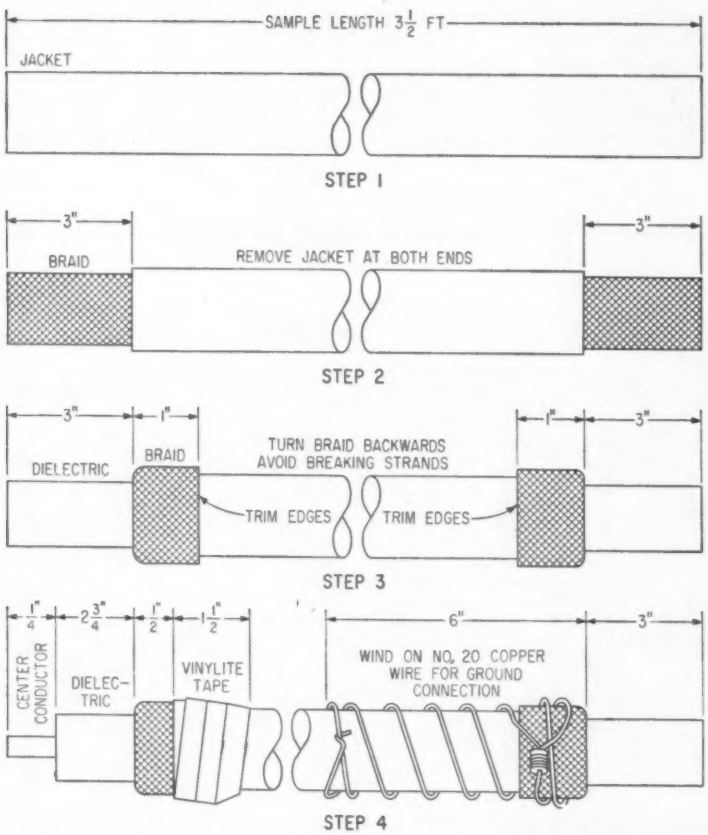

FIG. 1—These four steps represent an economical method of preparing cable specimens for corona testing

COAXIAL CABLE used with high voltages should be protected against harmful discharges that may occur within the cable or its connectors during operation. If voids within the cable dielectric become ionized, premature breakdown of the insulation can occur.

The ideal method for corona testing would be to test reels of coaxial cable. But because of the total capacitance of the reel, sensitive and expensive equipment is required. Even if such equipment is used, no method is available for locating the points of discharges in a cable. Several manufacturers of high-voltage cable check the dielectric core of the cable which ensures that no voids are present between the inner conductor and the dielectric or within the dielectric.

At the last Government-Industry meeting of MIL-C-17, the U. S. Army Signal Research and Development Laboratory recommended the use of 5 picocoulombs as the level of sensitivity to be used for testing for corona in r-f cables and USASRDL recommended that methods described here be adopted. Such action would permit comparison of corona results from several manufacturers and ensure that the same

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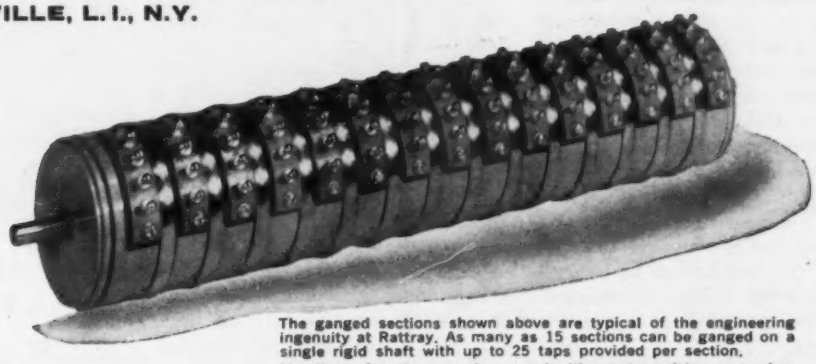

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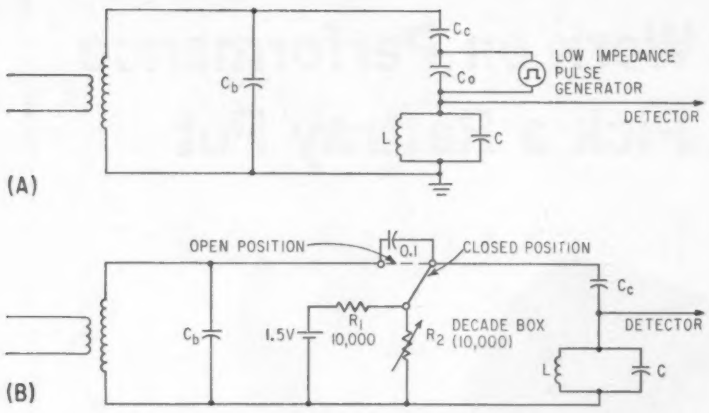

FIG. 2—Two test and calibration circuits which can be used for corona testing of cables

requirements are being met.

The preparation of the cable specimens for corona testing is of paramount importance. If the discharges occur at the terminations of the cable sample, the corona extinction voltage of such a specimen does not reflect the inherent cable performance and rejections of cable may result. Consequently for the proper testing of the cable and for his own protection, the manufacturer should make sure that the terminations of the samples are corona free.

An economical and time saving method of preparing the cable specimens for corona testing is illustrated in Fig. 1. After the specimen is prepared, the ends are dipped into an insulating oil to immerse the exposed braid about ¼ inch below the oil surface. Air bubbles should be excluded from the end of the braid under oil. Connection to the inner conductor should be made so as to allow adequate separation from the braid.

The tape should not be applied over the dielectric of the cable. Where the manufacturer of the cable has made the ground connection in the middle of the sample by removing a section of the jacket and then wrapping it with several turns of wire, this braid tends to become loose when the jacket is removed. Care should be taken to wrap such wire tightly.

Use of a resonant circuit for conducting corona tests on coaxial cables offers excellent sensitivity and a means for determining the size of the discharge. The simplest form of such a circuit would be inductor coupling with a resonant frequency in the neighborhood of 100 Kc and 1 Mc.

A test and calibration schematic is shown in Fig. 2A where C_c is the capacitance of the cable specimen, C_b is the capacitance of the coupling capacitor which must be corona free at the test voltage, and $C_b >> C_c$.

The coupling device connects to the input of an amplifier, which has a gain consistent with the capacitance of the test specimens. If the capacitance is in the order of 100 pf, then the signal produced by a corona discharge of 5 picocoulombs will be between 15 and 50 millivolts, and the amplifier of an oscilloscope with 15 mv per in. sensitivity at the resonant frequency will be adequate. If the specimen is a length of cable with a capacitance of 30,000 pf, for example, the signal produced by a 5 picocoulomb discharge will be between 15 and 156 microvolts and a preamplifier with a gain of about 300 at the resonant frequency will be needed between the coupling device and the oscilloscope.

One example is offered. In Fig. 2A capacitor C_b may have a value of larger than 1,000 pf and must be corona free at the test voltage. Using inductor coupling, L is an r-f choke with a value of 10 mh, and C, which includes the distributed capacitance, is 200 pf to yield a resonant frequency of about 100 Kc.

One variation of this circuit is where the cable specimen is placed across the secondary of the transformer and a blocking capacitor in series with the tuned circuit. The value of the latter may be about 100 pf. All stray capacitances should be kept to a minimum as they affect the sensitivity.

The calibration is performed as follows. Cable capacitance C_c is accurately measured. The cable specimen is then charged to a voltage V_c sufficient to provide a minimum charge of 5 picocoulombs. The specimen is then discharged into the resonant circuit with the deflection observed on the scope. This deflection should be at least ½ inch for the necessary accuracy. The repetition rate of the pulse generator should be approximately 100 pulses a second. Duration of the pulse should be 10 microseconds or longer, with a rise time of 0.1 microsecond or less. The output impedance of the generator should be 100 ohms or less. The loss of charge is then calculated by:

$$\text{picocoulombs per inch deflection} = \frac{C_c\,(\Delta V_c)}{\text{inches of deflection}}$$

where C_c is in picofarads and ΔV_c is in volts.

An alternate method for the calibration is by using the circuit of Fig. 2B. The 0.1-microfarad capacitor must be of noninductive internal construction and must be mounted on the switch with a minimum of lead length to minimize external inductance.

With the switch in the closed position, the cable specimen is charged to a voltage V. When the switch is opened, the specimen discharges into the resonant circuit and deflection is observed on the oscilloscope. The loss of charge is the same as described in the previous method.

The author thanks W. T. Starr of the general engineering laboratory, General Electric Co., Schenectady, New York for his help in preparation of this report.

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Synchronizer Forms Composite Tv Pictures

TELEVISION images from one source can be superimposed on those from a second source with a newly developed Japanese synchronizing system. Called an intersynchronizer, the unit can also wipe out part of the picture from one source and replace it with that from another to form a composite display. Virtually jitter-free performance is claimed for the arrangement as a result of the short time required for the two sources to be synchronized.

The intersynchronizer, developed by Shiba Electric, Tokyo, can be used with two video tape recorders or with one recorder and the studio television camera. Results obtained with the system are shown in the photographs.

The complete system comprises a servo control system for recording and another for reproduction. A total of 30 to 40 electron tubes are used in the unit, which is mounted on a chassis 500 mm wide and 600 mm long.

Major parts of the recording portion of the system are shown at the top of the figure. The vertical synchronizing component of the composite video input signal is separated and the resulting pulses are integrated. The vertical synchronizing signal is quadrupled in frequency, forming a 240-cps output. This output signal is applied through a phase shifter and discriminator to the amplifier that provides driving power for the recording head.

The 60-cps vertical synchronizing signal is also applied to a discriminator for phase comparison with the 240-cps control signal from the four-unit roating video head. If a phase error exists, an error signal is provided to the phase shifter so that phase coincidence can be restored.

The 240-cps signal from the rotating video head is also used to further stabilize rotational velocity of the drive motor for the video head. A velocity-error detector provides a corrective signal to the discriminator that feeds the drive motor amplifier to compensate variations in rotational velocity. Thus the vertical synchronizing component of the video signal is used to maintain constant rotational velocity of the video recording head.

Reproduction is accomplished with the arrangement at the bottom of the figure. If a live broadcast is to be used with a recording, the standard 60-cps vertical and 15,750-cps horizontal synchronizing signals are separated from the live and recorded composite signals. Each pair of synchronizing signals are separated from the live phase discriminator.

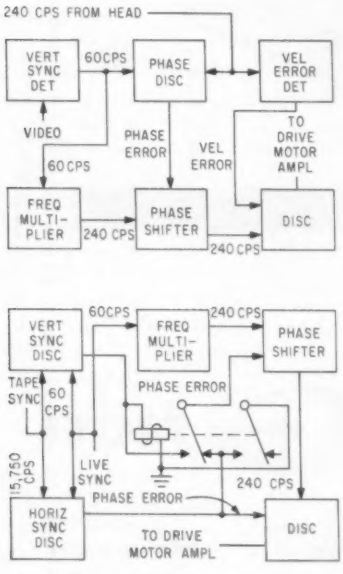
To achieve phase coincidence of the two vertical synchronizing signals, an error-detecting relay is energized by output from the vertical phase discriminator. The relay contacts connect output from the vertical phase discriminator to the phase shifter, while preventing horizontal phase discriminator output from reaching the phase shifter.

When the two vertical synchronizing signals are in phase, the error-detecting relay returns to its original state. Thus output from the horizontal phase discriminator is connected to the phase shifter.

As well as maintaining correct phase relationships, this arrangement compensates minor variations in drive motor rotational velocity. In addition, the 60-cps vertical synchronizing signal is quadrupled. Although not shown, the 240-cps signal from the video head is compared in phase with this signal as in the recording arrangement. Velocity errors are corrected as before by altering phase of the signal that is supplied to the drive motor.

Performance of the system is such that phase coincidence within 0.1 μsec is said to be achieved within 1 second. Thus jitter is practically eliminated.

When reproduction from the video tape recorder is first initiated, only 2 seconds are required to achieve synchronization with the station signal. This fast response is possible because the circuit synchronizes the station signal that initiates a vertical frame with the



Vertical synchronizing signals control recording head velocity at top, while playback at bottom uses both pairs of synchronizing signals

One live and one recorded or two recorded video signals can be used to produce composite or superimposed images

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SM 325-2	0-325	0-2	
SM 14-15	0-14	0-15	5¼"
SM 36-10	0-36	0-10	
SM 75-5	0-75	0-5	
SM 160-2	0-160	0-2	
SM 325-1	0-325	0-1	
SM 14-7	0-14	0-7	3½"
SM 36-5	0-36	0-5	
SM 75-2	0-75	0-2	
SM 160-1	0-160	0-1	
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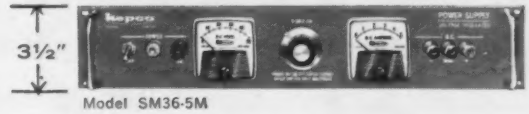

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METERS OPTIONAL: Model Nos. listed in table are for unmetered units. To specify metered units, add "M" to Model No. (e.g. SM 14-30M)

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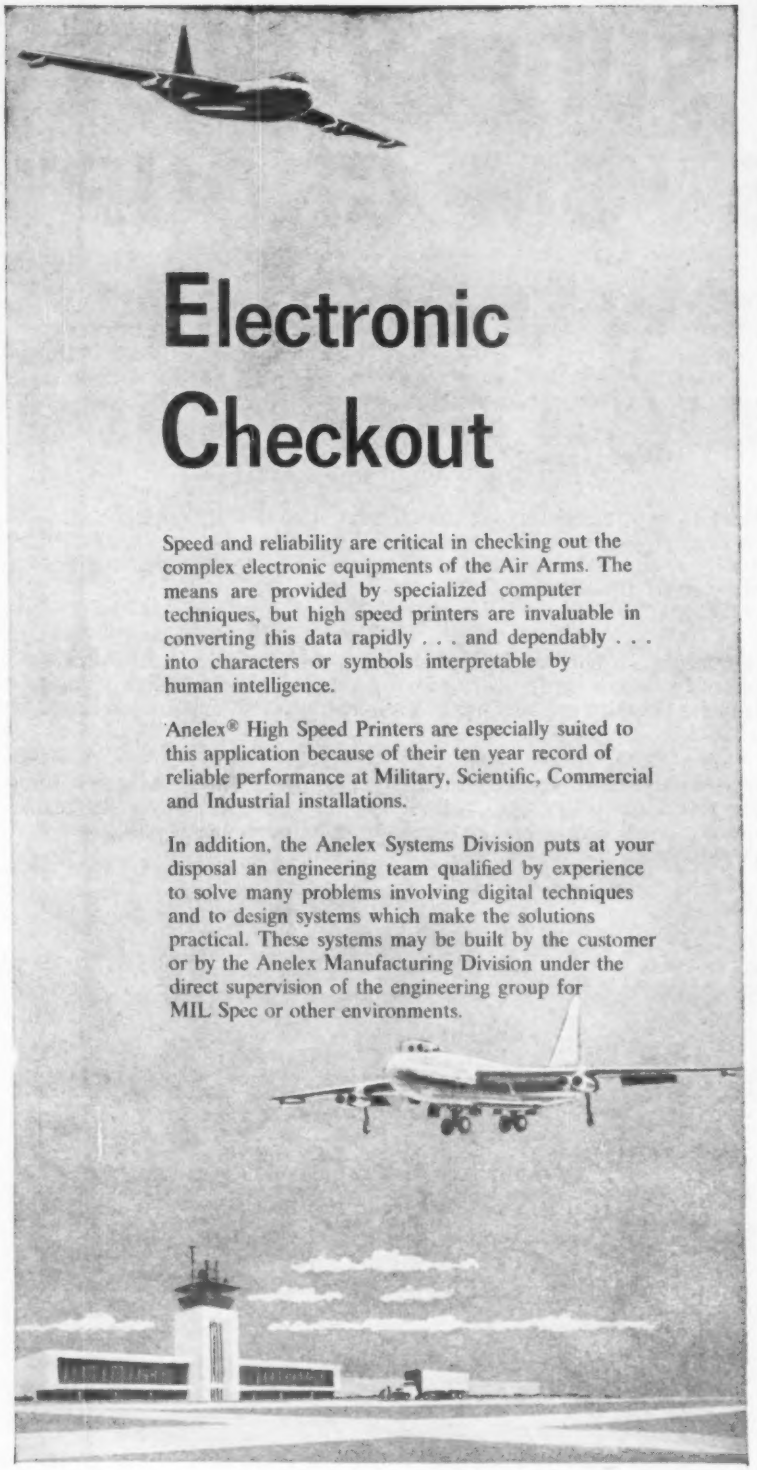

Electronic Checkout

Speed and reliability are critical in checking out the complex electronic equipments of the Air Arms. The means are provided by specialized computer techniques, but high speed printers are invaluable in converting this data rapidly . . . and dependably . . . into characters or symbols interpretable by human intelligence.

Anelex® High Speed Printers are especially suited to this application because of their ten year record of reliable performance at Military, Scientific, Commercial and Industrial installations.

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correct recorded vertical synchronizing signal. Thus the correct recording track is selected before the recorder begins reproducing.

Shiba Electric expects to begin production of the intersynchronizer during the fall. Each unit will sell for about $20,000 and the firm plans to make about five units a month.

Solid-State Unit Tests Airborne Transponders

OPERATING simplicity is a key feature in a recently designed airborne test set. The unit was developed to check the performance of IFF transponders or ATC radar beacons. Operation of the transponders can be monitored while in flight, or a test of their operating condition can be incorporated into preflight checkout routines.

The transponder tester was developed by the Stromberg-Carlson division of General Dynamics, and designation of the test set is Model SC-770. By using semiconductor devices, it was possible to limit weight of the compact test set to less than three pounds. In addition to the savings realized in space and weight, the use of solid-state components has resulted in holding power requirements down to an extremely low level.

The test set is comprised of two subassemblies. The basic interrogator circuits have been separately packaged for installation in the aircraft at a convenient location. The other part of the test set is the control box, which was designed to be mounted on the instrument panel of the aircraft.

A basic design aim in development of the transponder tester was simplicity of operation. This effort has resulted in an easily operated test set that provides the operator with a go-no go indication of transponder operating condition in flight or before take-off.

All that is required for operation of the new tester is that a pushbutton switch mounted on the control box be depressed. By closing this switch, the interrogation circuits are energized. The function of these circuits is to interrogate the transponder to which they are connected.

Visible indication of the condition of the transponder under test is provided by indicator lamps mounted on the control box. When the push-button is depressed to interrogate a transponder, flashing of the indicator lamps on the control panel will indicate that the operating condition of the transponder at least meets minimum performance requirements satisfactorily.

Short, High-Intensity Light Pulses Produced

DISCHARGING a coaxial capacitor in an air gap has made possible the production of light pulses as short as 0.3 μsec duration. The high-intensity bursts of light permit stopping high-speed events for photographic study. It can illuminate models, gases or chemicals reacting at high speeds.

The new light source was developed by Avco Research and Advanced Development division in Wilmington, Mass. It was originally designed to study very high velocity flights of advanced model nose cones for the Air Force Titan and Minuteman missiles.

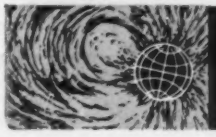
The high-intensity spark light can be incorporated into instrumented shadowgraph and schlieren systems. In the basic shadowgraph system, it can be used alone like the open-shutter, flash-bulb technique. The spark pulse can be synchronized with a Kerr cell shutter, and a voltage pulse is provided to initiate other measuring instruments.

Spark light duration ranges from 0.3 to 1 μsec in the four models of the light source. Diameter of the point source of light depends on energy level and can vary from 0.015 to 0.06 inch. Energy level can vary over a range of 2 to 20 joules.

The 5-inch diameter cylindrical package in which the unit is housed is 12½ inches long with a coaxial discharge path. The outer case of the cylinder functions as an r-f shield.

When the unit is originally packaged, its position must be established. However, after original positioning, the component package can be removed, adjusted and returned into the case without disturbing its optical alignment.

Whether your servo application is in the challenging under-water environments of the history-making Skate or in the severe blast-off environment of the Polaris, you now can design your equipment or system smaller and better with an IMC servo ■ New advances in sub-miniaturization and motor performance ensure top operating characteristics for your systems applications. Size 5 through 18, high torque-to-inertia ratio, encapsulated for extra ruggedness, broad range of gear ratios, meet latest MIL environmental specifications ■ IMC engineers are ready to assist you in your servo design needs. Take advantage of their special servo know-how. Chances are they will save you time and money . . . plus provide you with a motor that completely fulfills your particular requirements ■ Write for additional technical information to:



imc Magnetics Corp.
570 MAIN STREET/WESTBURY, LONG ISLAND/NEW YORK/EDGEWOOD 4-7070

Printed Contact Relay Uses Permanent Magnet

THE EMBODIMENT shown in Fig. 1 is a relay concept designed to save space and weight, reduce assembly time, and improve reliability. The Printact relay, developed by Executone Inc., L. I., N. Y., mounts directly on a printed circuit board. Intermediate connections to fixed contacts are eliminated by doing away with the contacts themselves.

The moving contacts on the relay armature assembly mate directly with conductors on the printed circuit board. The conductor pattern is designed by the user to meet his specific application problem. A few typical arrangements are illustrated Fig. 1.

The armature assembly carrying the moving contacts is held in position against the edge of one of the U-shaped fixed magnetic members by a small ceramic permanent magnet. Application of an electromagnetic field opposing the field of the permanent magnet causes the armature to rotate.

The only moving part is the balanced armature assembly on which the contacts are mounted. This absence of mechanical linkages and return springs eliminates a major source of relay troubles and maintenance costs.

The relay is accurately positioned on the printed circuit board by studs which pass through punched holes in the board. It is held in position by a simple spring. Only the coil terminals require soldering.

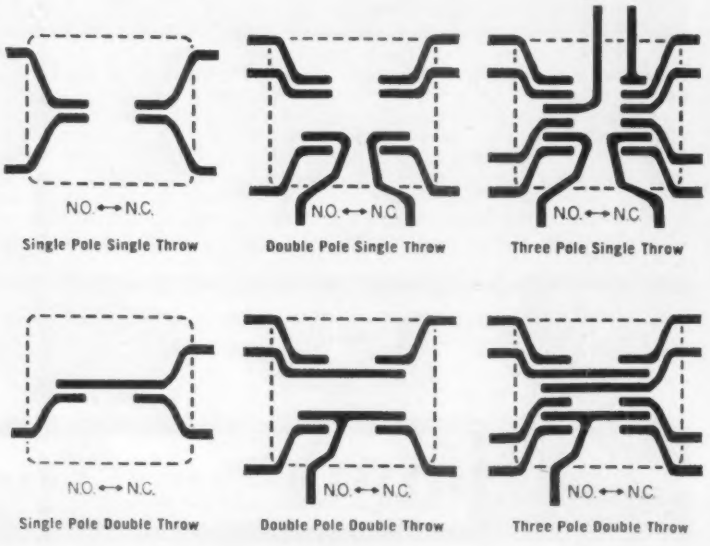
As described by A. C. Bernstein, President of Executone, the magnetic motor assembly is molded in a high-impact plastic. The ceramic biasing magnet is positioned between two U-shaped pole pieces made of No. 5 relay steel (cadmium plated and hydrogen annealed after forming).

The pole pieces are assembled with the magnet between them to form an E-shaped structure with the coil (wound on a nylon bobbin) surrounding the center leg. The armature is normally biased against one leg of the E by the permanent magnet. When voltage is applied to the relay, the flux produced by the coil tends to attract the other end of the armature across the open air gap, at the same time bucking the flux of the permanent magnet and tending to cancel the attractive force across the closed gap. Sufficient current through the coil will cause the armature to rotate; removal of this current permits the permanent magnet to restore the armature to its first position.

The use of a permanent magnet, whose restoring force tends to decrease rather than increase as the armature rotates, accounts for the high sensitivity and enhances the snap action of the relay compared to a conventional relay with a return spring.

The armature and moving contact assembly consist of a No. 5 relay steel armature, a Mylar insulator, a high-impact plastic molding, and heat treated beryllium-copper springs with bar palladium contacts. The springs are pre-stressed during assembly to provide uniform contact pressure without any hand adjustment. All tolerances are picked up automatically by the prestressing of the springs and the form of the plastic mold. The balanced armature construction gives a high degree of freedom from shock and vibration which, together with the basic simplicity of the design and absence of hand adjustment, accounts for the high reliability of the relay.

The preferred printed wiring base material is glass cloth epoxy although other materials may be used. Conductor material is two-ounce copper, 0.0028 in. thick, and



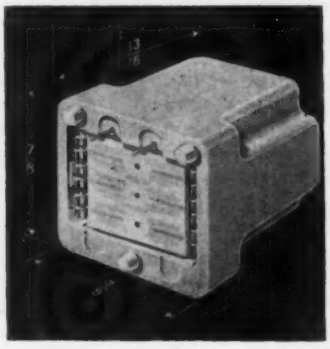


FIG. 1—Printed contact permanent magnet relay (above) mates directly with conductors on printed circuit board. Typical configurations are shown (left)

- *improved performance and characteristics*
- *decreased size, weight and power consumption*
- *functional replacements for Military types TD97 and TD98*

Rear view of a Multiplexer-Demultiplexer Shelf, Type 250 Model 1, showing 2 Transistorized Power Suppliers and Changeover Relay.

New ALL-TRANSISTOR

NORTHERN RADIO MULTIPLEXER and DEMULTIPLEXER

Type 248 Model 1 Type 249 Model 1

The new Multiplexer, Type 248 Model 1 (functional replacement for Multiplexer TD97-FTG-2), and Demultiplexer, Type 249 Model 1 (functional replacement for Demultiplexer TD98-FGR-3) are intended for use with twin-channel, single-sideband radio circuits operating in the high-frequency range. Their purpose is to derive two voice-frequency circuits from each of the radio channels. By means of frequency division multiplexing, the radio bandwidth from 200 to 6000 cps is divided into two transmission circuits, each with a bandwidth from 375 to 3025 cps. Four such vf circuits are derived from the twin-channel radio, and these are used to transmit carrier telegraph signals or to provide telephone or facsimile service.

The Multiplexer and Demultiplexer are designed to slide into the Northern Radio Type 250 Model 1 Shelf, which accommodates two each Multiplexers or Demultiplexers, or one each Multiplexer and Demultiplexer.

Two Multiplexers, Type 248 Model 1, are required for full utilization of the capacity of a radio transmitter. One is used to transmit telegraph, telephone, or facsimile signals from two vf circuits to the radio channel designated as sideband A. The second Multiplexer performs the same function for sideband B. In this way four vf circuits are applied to the twin-channel radio transmitter.

Two Demultiplexers, Type 249 Model 1, are required for full utilization of the capacity of a radio receiver. One is used to receive telegraph, telephone, or facsimile signals for two vf circuits from the radio channel designated as sideband A. The second Demultiplexer performs the same function for sideband B. In this way four vf circuits are derived from the twin-channel radio receiver.

The Multiplexer and Demultiplexer are transistorized equipments, including necessary bandpass filters, line amplifiers, carrier frequency sources, modulators and attenuators. The Multiplexer requires a nominal 14 volts DC at 125 milliamperes; the Demultiplexer, approximately 200 milliamperes at the same voltage. The power supply is normally provided from the Northern Radio Power Supply, Type 223 Model 1, which is plugged into the rear of the Type 250 Model 1 Shelf.

WRITE FOR FURTHER INFORMATION

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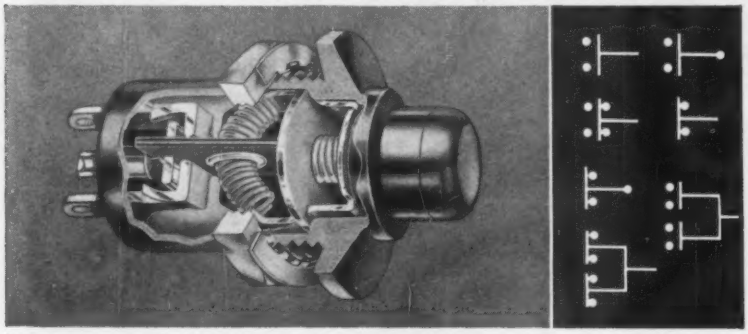

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VECTOR ELECTRONIC COMPANY

1100 FLOWER STREET, GLENDALE 1, CALIFORNIA

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Printed Contact Relay Data

Operating Voltage	Coil Resist. ± 10%
6-v d-c	125 ohms
12-v d-c	500 ohms
24-v d-c	2000 ohms
Power consumption	300 mw (at rated volt)
Pull-in	80 percent rated volt
Switching arrangement	1, 2, or 3 pole single or double throw

Contact rating @ 24-v d-c:
Minilife (operations) contact load (amps)

5,000,000	dry circuit
1,000,000	0.5 Resis.
500,000	1 Resis.
100,000	2 Resis.

Based on recommended printed circuit

Contact material	bar palladium
Max. ambient temp	70 C
Operate time	10 ms (at rated voltage)
Dielec. test	1,000 v rms 60 cps
Weight	0.8 oz.
Dimensions	7/8 × 7/8 × 13/16

the contact areas should be plated with rhodium over nickel, although other board and contact materials may be use.

Typical operating specifications are given in the Table. It should be noted that the contact rating for minimum life is based on the recommended printed circuit board material and contact structure. A typical application is shown in Fig. 2. The equipment shown is a doctor's register for hospitals. Using conventional standard relays, a system accommodating location data for 400 doctors required five bays of equipment using a total volume of 1,165 cu. ft.; the identical system redesigned to employ the Printact relay concept requires only 345 cu. ft.

A principle advantage, in addi-

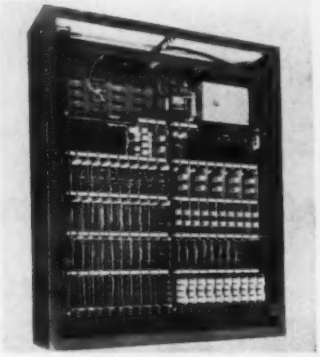


FIG. 2—Doctor's register, redesigned to employ the printed contact relay concept, achieves significant volume reduction

tion to cost, space and weight savings associated with the new concept, is reliability. The pre-adjusted, pre-stressed contact springs assure constant pressure. All of the tolerances are designed into the precision tooling for the armature assembly and the micro-processed contact springs. The solid molded magnetic motor assembly serves as a dust cover for the entire contact system. If desired, further protection may be achieved by applying a fillet of epoxy cement around the relay after it is mounted on the printed wiring board.

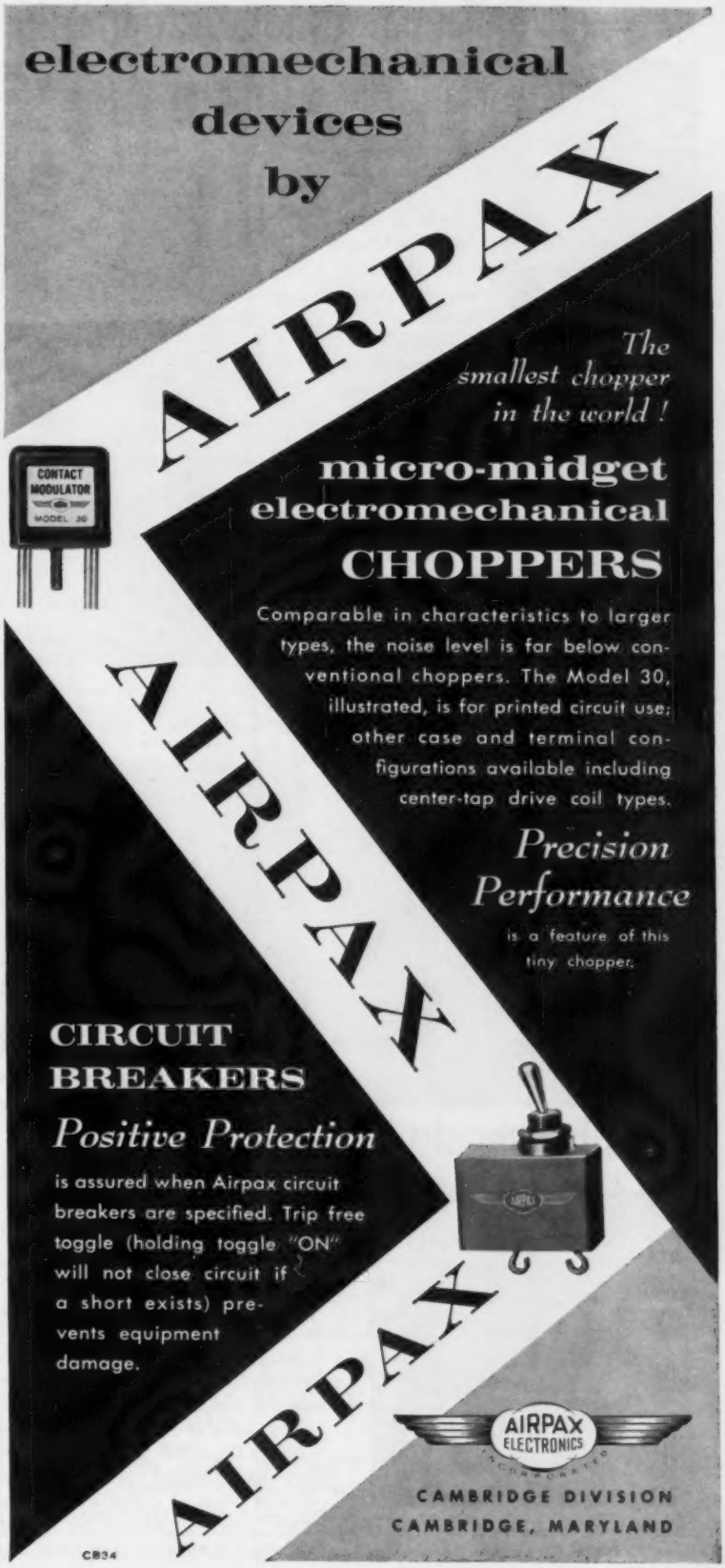
The successful application of this new concept in Executone's own equipment led to the decision to make this component available to the electrical and electronic industries.

High Viscosity Resin For Thermoplastic Films

AVAILABILITY of Resin D-566, a newly developed plasticized dispersion of a high viscosity polyvinyl butyral resin, was announced by Shawinigan Resins Corporation, Springfield, Mass.

The material is potentially useful where a low tack, abrasion resistant, high strength film with high adhesion is required, according to the company. It can also be combined with water soluble or water dispersible thermosetting resins. Suggested areas of application include aqueous-based baking primers, decorative and protective coatings for metal, wood, glass, and other materials, textile finishing, binder for non-woven fabrics, and greaseproof or washable coatings for paper and textiles.

Upon drying at elevated temperatures, Resin D-566 produces thermoplastic films having high adhesion to porous and non-porous surfaces. Films dried at room temperature are strippable, non-tacky, continuous, and water resistant. The plasticizer used in Resin D-566 is non-migratory and gives the film good heat and color stability. Tensile strength of this dried film is about twice that of Butvar Dispersion BR, Shawinigan Resin's standard product. Elongation is only half that of the BR Dispersion.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AIRPAX
The smallest chopper in the world!
CONTACT MODULATOR
MODEL 30
micro-midget electromechanical CHOPPERS
Comparable in characteristics to larger types, the noise level is far below conventional choppers. The Model 30, illustrated, is for printed circuit use; other case and terminal configurations available including center-tap drive coil types.
Precision Performance
is a feature of this tiny chopper.
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Positive Protection
is assured when Airpax circuit breakers are specified. Trip free toggle (holding toggle "ON" will not close circuit if a short exists) prevents equipment damage.
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Resistance Heater Seals Gas in Can

VARIOUS SOLDERING TECHNIQUES, including one which seals the housing by resistance heating as it is filled with inert gas, are used by International Business Machines Corporation to assemble an airborne unit.

The unit is made at IBM's Federal Systems Division, Owego, N. Y. Most of the circuitry is assembled conventionally on printed wiring boards. The boards are automatically flow-soldered, ultrasonically cleaned and mounted on sturdy aluminum bars so they fit snugly into the housing.

However, each unit contains several miniature tubes attached to the board by wire leads. For protection, the tubes and some stand-off capacitors are supported in semicircular metal bands conforming to the inside surface of the can. Tube holders are partial cylinders soldered to the bands. The bands are secured to the aluminum bars. In addition to support, the bands help cool the unit by transferring heat from the tubes to the can.

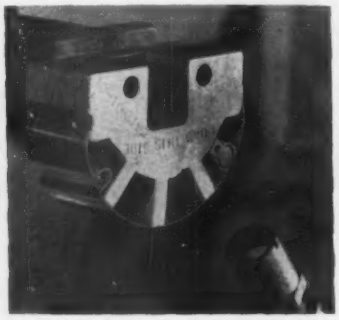
The tube holders are torch-soldered to the bands as a preliminary step. The soldering fixture is a semicircular block of metal with an asbestos lobe for each tube holder. Holders are slipped over each lobe and the band is clamped over the holders. Open spaces on either side of each lobe permit the torch flame to evenly heat each holder as solder is applied.

Can lids and connectors are soldered together as another subassembly. Heat is supplied by a hotplate which also serves as the soldering mixture. The hotplate is recessed so pairs of lids and connectors are in soldering position.

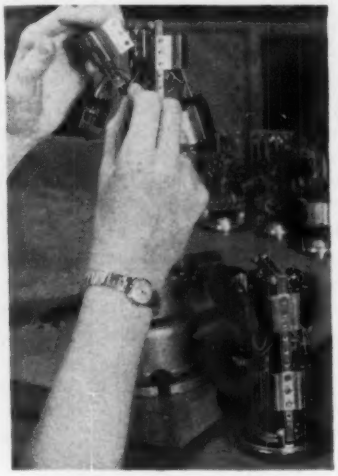
After units are inspected, tested

Sealing fixture is loaded with can-type housings before bell jar is lowered. Cans are evacuated and gas filled through hole in bottom

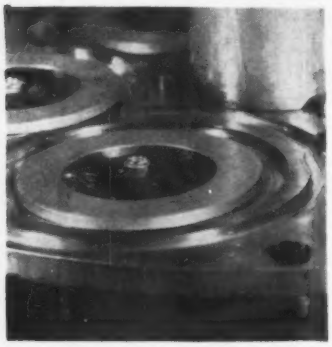
Fixtures clamp cans over sealing electrodes



Tube holders are torch-soldered to bands

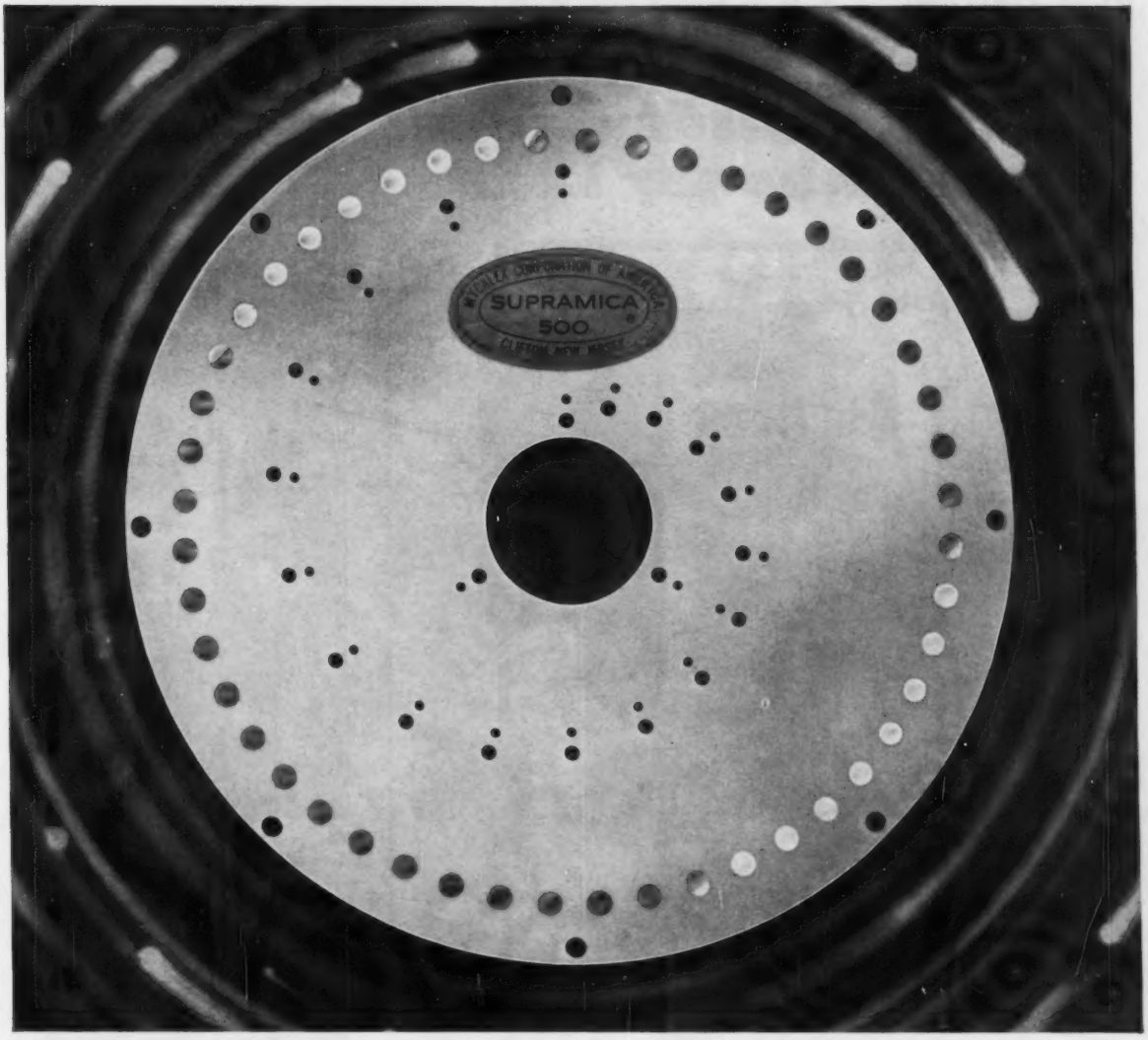


Assembler slips tubes into holders in one of last steps before sealing



Closeup of loaded resistance heating electrode

When the requirements seem impossible...



48 precious metal contacts on a 12" circle... maintaining .0003 T.I.R. planar tolerance

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The specifications are most demanding, the requirements highly critical . . . plates must be flat within .0003" and embody precision-machined recesses to accept 48 pure silver contacts. The angular displacement of the contacts is held to ±1 minute. The combination of contacts and SUPRAMICA 500 together must accept a 2 micro inch surface finish. The application requires that these tolerances are guaranteed for the life of the commutator during which the environmental conditions run the gamut of humidity and temperature.

The MYCALEX fabricating facility is not only fully qualified to furnish the fabrication of such parts but will design and provide required hardware. For gauge-like specifications on large production runs or short prototype quantities . . . our engineers are ready, capable, and equipped to assist you with your design and production requirements. Write for information on SUPRAMICA ceramoplastics offering maximum temperature endurance (unstressed) up to +1550°F. and SYNTHAMICA® synthetic mica with maximum temperature endurance (unstressed) up to +2000°F. . . . the family of the world's most nearly perfect insulation materials.

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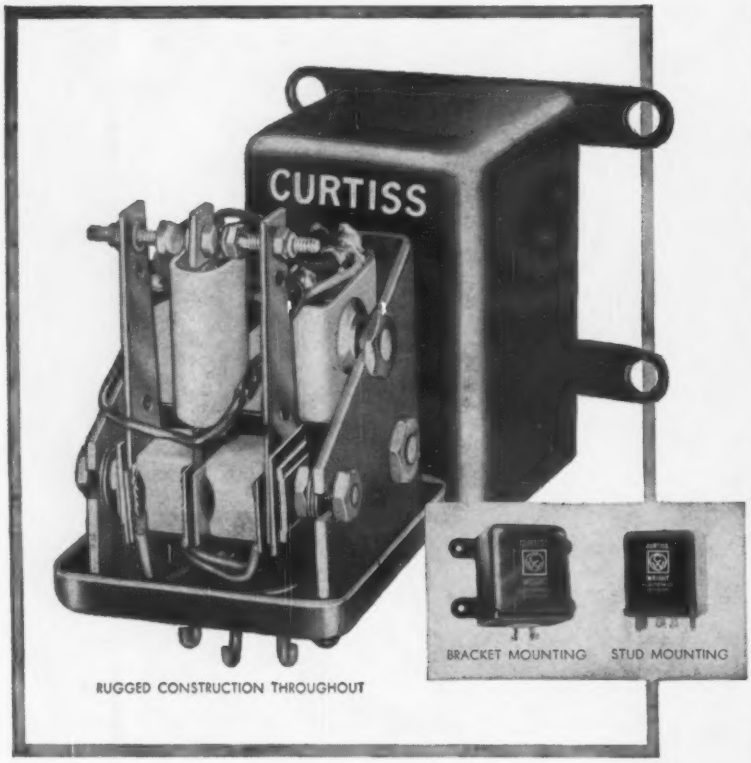
NEW Time Delay Relays

INSTANTANEOUS RESET... VOLTAGE-TEMPERATURE COMPENSATED



Designed with an instantaneous reset feature, these relays provide the same time delay for a series of cycles when temperature and voltage vary.

They are pre-set from 3 to 180 seconds, are chatter-free and will withstand severe shock and vibration. Because of this unique combination of features, these relays are now being used in such new circuit applications as:

Sequential timing for missiles • Automatic reset on digital readout equipment • Oscillator stabilization • Overload protection • Computer sequencing

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Curtiss-Wright Stepping Motors convert digital pulses into mechanical work or motion. Units are bi-directional with high starting torque.

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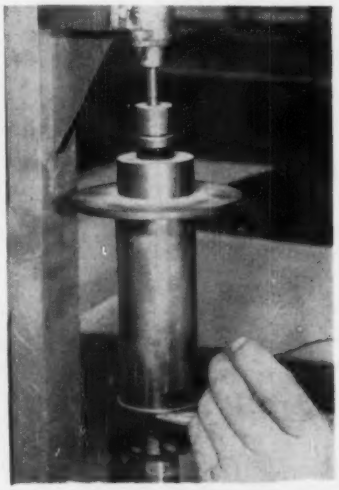
and placed in the cans, lids are soldered in place. The solderer uses a fixture which presses the lid to the can while revolving so solder can be flowed easily into the joint with an iron.

The can is evacuated and backfilled with a mixture of nitrogen and helium, through a small hole in a recess in the bottom of the can. The hole is sealed by soldering a disk over the recess with a preform solder ring.



Lid is sealed to can on revolving fixture. Iron is held under lip

Connectors are soldered to lid on hotplate fixture

The sealing operations are performed on fixtures contained in a bell jar. Each can is positioned in a fixture so the hole is over an electrode which can be raised. The electrode is loaded with the sealing disk and solder ring. After the evacuation and gas filling cycle, the electrode is raised, soldering the disk to the can by resistance heating.

Tumbling Plates Zinc On Small Steel Parts

HYDROGEN EMBRITTLEMENT of zinc plating on high carbon steel and spring steel is avoided by a mechanical plating method used by the George K. Garrett Co., Inc., Philadelphia, Pa. After cleaning, the parts are placed in a tumbler with powdered zinc, promoting compound, water and glass beads of varying size. The impacting action of the beads plates the zinc to the steel. Parts are evenly plated and require no baking or aging. The process was first developed by Minnesota Mining and Manufacturing Co.

Infrared Finds Faults In Silicon Crystals

INFRARED is being used by Sylvania Electric Products, Inc. to find imperfections in silicon crystals. Copper is diffused into the sample and precipitates at the imperfection sites. Infrared light is passed through the sample and made visible by an infrared-sensitive tv pickup tube and closed-circuit tv receiver. Since silicon is transparent to infrared while copper is opaque, the imperfections show on screen.

Preassembled Cushions Cut Packaging Time

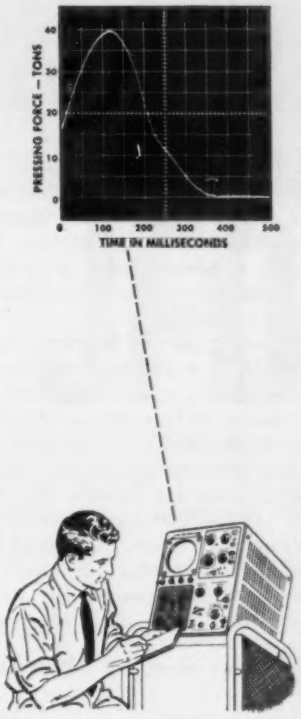
INSTRUMENT SHIPPING package adopted by Donner Scientific Company, Concord, Calif., is reported to **cut packaging time from 25 to three minutes.**

Packages formerly used required two cartons and the assembly of 12 pieces of material. The new package employs two preassembled, interchangeable cradles at top and bottom of instrument and one carton.

The cradles are made of polyurethane foam mounted on a piece of corrugated cardboard with a die-cut glue block rim. The instrument fits into the cradles so it rests on the foam three inches away from the carton's sides.

Tare weight of the new package is 7¼ pounds, 3¼ pounds less than the old package. It was designed and made by Tharco Containers, Oakland, Calif.

USING STRAIN GAGES?



Information from strain gages and many resistive, capacitive, and inductive transducers can be displayed on the face of a cathode-ray tube . . . with the Type Q Plug-In Unit and any Tektronix Plug-In Oscilloscope.

You get a detailed picture of this information plotted against time, from which accurate measurements can be made with ease. The illustration, a plot of a press stroke, is an example of a quality-control application.

It's quite likely that your lab is already equipped with one or more Tektronix Plug-In Oscilloscopes. If so, the only additional expenditure will be the price of a Tektronix Type Q Plug-In Unit—$300 f.o.b. factory.

The Type Q Unit plugs directly into these oscilloscopes: Tektronix Types 531, 531A, 532, 533, 535, 535A, 536 (for X-Y plots), 541, 541A, 543, 545, 545A, 551 and 555 (dual beam), and all their rack-mounting versions. It can also be used in the Type 81 Plug-In Adapter with both the Type 581 and Type 585, and in the Tektronix 127 Preamplifier Power Supply with any standard laboratory oscilloscope and many other readout devices.

Maximum sensitivity of the Type Q is 10 microstrain/division when used with a single strain gage with a gage factor of about 2. Frequency range is dc to 6 kc (3 db down), with excellent transient response.

For complete information, or assistance with strain-gage and other transducer readout problems, please call your Tektronix Field Engineer.

Tektronix, Inc.

P. O. Box 500 • Beaverton, Oregon
Phone Mitchell 4-0161 • TWX—BEAV 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: Albuquerque, N. Mex. • Atlanta, Ga. • Baltimore (Towson, Md.) • Boston (Lexington, Mass.) • Buffalo, N.Y. • Chicago (Park Ridge, Ill.) • Cleveland, Ohio • Dallas, Texas • Dayton, Ohio • Denver, Colo. • Detroit (Lathrup Village, Mich.) • Endicott (Endwell, N.Y.) • Greensboro, N.C. • Houston, Texas • Indianapolis, Ind. • Kansas City (Mission, Kan.) • Los Angeles, Calif. Area (East L.A. • Encino • West L.A.) • Minneapolis, Minn. • New York City Area (Albertson, L.I., N.Y. • Stamford, Conn. • Union, N.J.) • Orlando, Fla. • Philadelphia, Pa. • Phoenix (Scottsdale, Ariz.) • Poughkeepsie, N.Y. • San Diego, Calif. • San Francisco (Palo Alto, Calif.) • St. Petersburg, Fla. • Syracuse, N.Y. • Toronto (Willowdale, Ont.), Canada • Washington, D.C. (Annandale, Va.)
TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon • Seattle, Washington. Tektronix is represented in twenty overseas countries by qualified engineering organizations.

In Europe please write Tektronix Inc., Victoria Ave., St. Sampsons, Guernsey C.I., for the address of the Tektronix Representative in your country.

New On The Market

Data-System Transmitter

USES TELEPHONE LINES

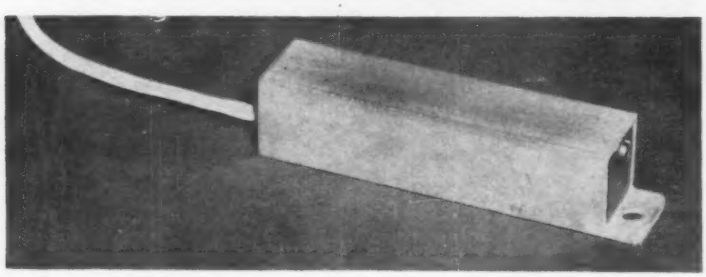
HIGH-SPEED data communication system transmits scientific data at a rate of 2,400 bits per second over commercial telephone lines more than 200 miles long. Operating experience indicates an error rate of less than one in one million bits transmitted, and these errors are detected by system logic before entry of data into computer.

Punched cards containing the input data are fed into a high-speed card reader at one end. The transmission logic in the system converts the data to a serial train of binary pulses. Check bits are added and the data is modulated for transmission. At the receiving end the data is demodulated, checked, and recorded on magnetic tape for entry into computer facilities. Accuracy of transmission is assured by both lateral and longitudinal parity checks.

Punched cards, punched tape, magnetic tape and keyboard inputs are available, and outputs may be on magnetic tape, or on the S-C 3000 high-speed electronic printer. Slow inputs can be stored for rapid transmission and output. The system also provides voice communication over the same leased wire.

More information is available from Stromberg-Carlson Div., General Dynamics Corp., 445 Park Avenue, N. Y., N. Y.

CIRCLE 301 ON READER SERVICE CARD



Compensated Resistor

TEMPERATURE ADJUSTABLE

TEMPERATURE coefficient of the new Model 760 Temp-A-Just resistor can be adjusted externally without affecting the fixed resistance value.

Specifications include: temperature coefficient adjustment range from 10 ppm per degree C to 4,500 ppm per degree C; fixed resistance values from 100 ohms to 10,000 ohms; operating temperature range from −55 C to 150 C; resistance tolerance 1 percent at 25 C; power rating 1 watt.

Custom models will be furnished to meet special mechanical requirements and physical configurations. The variable coefficient resistors may be used to temperature compensate complete electronic circuits, printed circuit board modules or individual components such as transistors and solid state devices. Priced at $15.00 each in sample quantities, units are available from Conrad-Carson, Inc., 3110 Goddard Way, San Diego, Calif.

CIRCLE 302 ON READER SERVICE CARD

Current Recorder

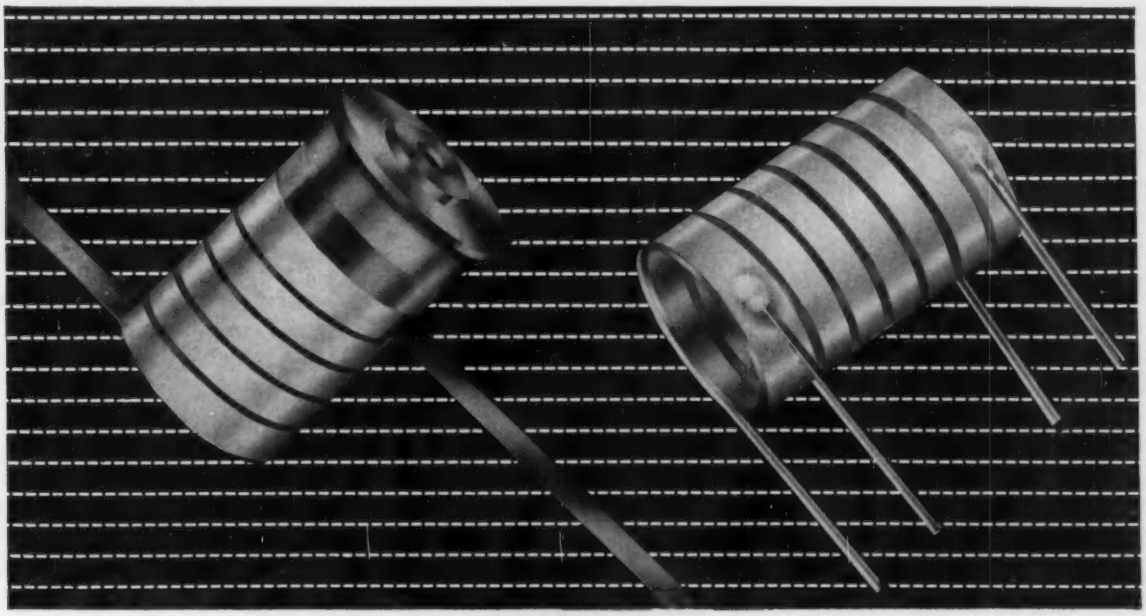
FIVE TO 600 AMPS A-C

SMALL ECONOMICAL chart recorder can be used with transducers in a-c current ranges from 5 amps to 600 amps. Either a portable clamp-on or a permanent pick-up type transducer is available, giving readings without a direct connection to the power buss. The ammeter is not sensitive to voltage and will read

and record the current directly onto a moving chart for a permanent record.

The recorders are available with variable chart speeds from 1 to 240 inches per hour. At one inch per hour, a roll of inkless chart paper gives a continuous 31 day record. Among its numerous applications, the recorder will indicate specific power loads at various times of the day, the location of a troubled area, precise on-and-off time for power equipment. It can be located up to 2,000 feet away from the current pick-up transducer. The unit can also be equipped with a low-current d-c motor so that it may continue recording during a power failure.

The Rustrak AC current recorder has all the features of the regular Rustrak automatic recorder



NEW FROM JFD FIXED MINIATURE METALIZED INDUCTORS

JFD now offers a complete line of fixed-value miniature Metalized Inductors in inductances to cover a wide variety of circuit application requirements

MODEL LF-1P010
ACTUAL SIZE

MODEL LF-2W008
ACTUAL SIZE

TYPICAL PANEL MOUNT JFD METALIZED INDUCTORS

Model	Inductance μh (± 5%)	Q Min.
LF-1P010	0.10	145
LF-1P025	0.25	135
LF-1P040	0.40	103
LF-1P070	0.70	120
LF-1P100	1.00	135
LF-1P200	2.00	180

Listed above are only six of 23 standard JFD Metalized Inductors available in panel mount and printed circuit types from .05 μh to 2.00 μh.

The new JFD Inductor series employs silver film permanently fused to a low loss dielectric glass cylinder. This lightweight monolithic construction achieves a new high in stability, durability and economy; a new low in temperature coefficient of inductance and distributed capacitance. Assures you of utmost reliability for critical circuit operation in severe environment.

JFD Metalized Inductors can also be designed to help solve any development, design, or production problem. The number of turns, types of windings, size and distributed capacitance, Q and other parameters can be designed to suit individual circuit requirements. Write for bulletin 223 for full specifications.

Features

1. Rugged construction affords unusually high stability under conditions of severe shock and vibration.
2. Use of glass dielectric assures low temperature coefficient of inductance and operation without derating over a wide range of extreme environmental conditions.
3. Low distributed capacity.
4. Special alloy plating protects metal parts from corrosion.
5. A high Q over a broad frequency range.
6. Silver plated copper leads.
7. Available in panel mount and printed circuit mount types.

JFD

PRECISION COMPONENTS FOR PRECISION PERFORMANCE

JFD ELECTRONICS CORPORATION

6101 Sixteenth Avenue, Brooklyn 4, New York

JFD WESTERN REGIONAL DIVISION
7311 Van Nuys Boulevard, Van Nuys, California

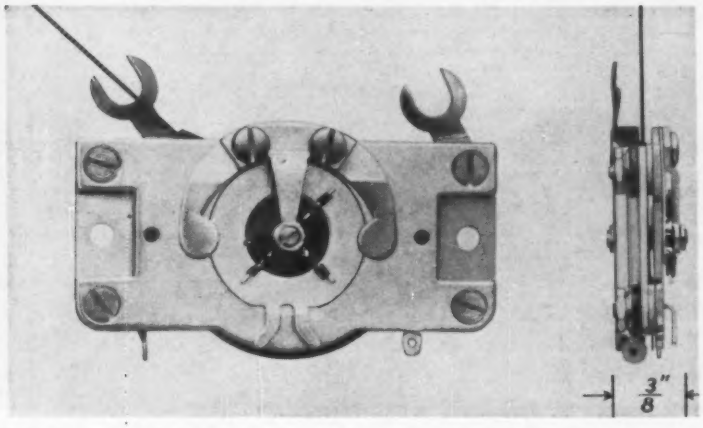
JFD CANADA LTD.
51 McCormack Street, Toronto, Ontario, Canada

JFD INTERNATIONAL
15 Moore Street, New York, N.Y.

VARIABLE TRIMMER PISTON CAPACITORS • FIXED METALIZED INDUCTORS • LC TUNERS.
FIXED AND VARIABLE, DISTRIBUTED AND LUMPED CONSTANT DELAY LINES • PULSE FORMING NETWORKS • DIPLEXERS

which includes portable or rack mounting and a rated accuracy of 5 percent; size is 3¾ wide, 5⅜ high by 4⅛ inch deep. Price with permanent transducer is $124.50; with the clamp-on transducer, $132.50. For further information write Rust Industrial Company, 130 Silver St., Manchester, N. H.

CIRCLE 303 ON READER SERVICE CARD



Thin Meter Movement

USES PRINTED CIRCUIT

NEW PRINTED circuit meter movement is announced by Interlab, Inc., 116 Kraft Ave., Bronxville, N. Y. The printed circuit coil allows the moving element structure to be kept thin and allows panel meters only ½ inch thick, exclusive of mounting studs, which also serve for electrical connections.

The magnetic circuit uses a ceramic ring magnet. Although ceramic magnets have low residual flux density, they also have long-term stability; the printed coil movement design provides full sensitivity. High dissipation ability of the open coils combined with resilient nylon bristles give an overload capacity of 10,000 percent. A range of movements with current ratings from 1 ma to 1 ampere are available with accuracy of 1½ percent. Higher accuracies are available on special order.

CIRCLE 304 ON READER SERVICE CARD

Image Intensifier

HIGH LIGHT THRESHOLD

A NEW high-vacuum tube, type WX-4047, which intensifies light radiation by electronic means, is available from the Westinghouse Electronic Tube Div., P. O. Box 284, Elmira, N. Y. The tube produces an image of reduced size whose brightness is increased by a factor of 2,500 (minimum) for actinic blue input radiation, by 1000 for input radiation at a color temperature of 2,870 degrees K.

Incoming radiation impinges on a five-inch photosurface which converts the light image to an electron image. Deposited directly on the internal surface of the polished bulb face, the photo cathode functions as an integral part of an external optical system. After conversion, the electron image is focussed and accelerated toward an aluminum backed phosphor screen.

Through use of short-persistence P15 phosphor, brightness decays to 10 percent in 2.0 microseconds. Input resolution is 75 line pairs per inch and the threshold for imaging is approximately 10^{-7} foot-candles. Maximum ratings are 30 kilovolts (anode screen to photocathode) and 1-milliampere peak pulse anode screen current. The tube weighs 6½ pounds, has a maximum diameter of 8⅛ inches, and is 15¾ inches long.

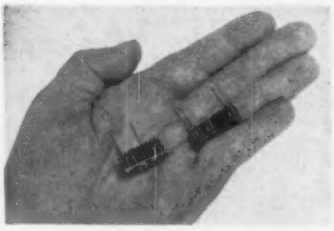
CIRCLE 305 ON READER SERVICE CARD

Crystal Oscillator

SHAPED WAVEFORM

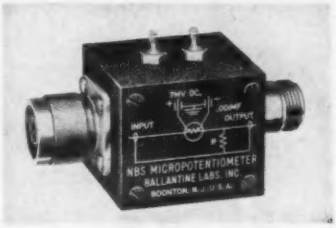
NEW M-3 Mini-Module crystal oscillator is announced by Monitor Products Co., 815 Fremont Ave., S. Pasadena, Calif. Modules include one for crystal circuits and one for output circuits.

The oscillator module is 1 by ½ by ⅜ inch (less crystal) and the output module is ⅞ by ½ by ⅜ inch.



Each module weighs less than one oz. Temperature range is from −55 C to 90 C. Vibration is 20 g, 50 milliseconds, with special mounting of crystal. Operating altitude extends to deep space, moisture rating to 100 percent relative humidity. Oscillator module provides 1 v rms into 2,000 ohm load. Output module provides sine or square waves or pulse.

CIRCLE 306 ON READER SERVICE CARD



Lab Voltage Standard

D-C TO 900 MEGACYCLES

A NEW micropotentiometer for use as a relative or absolute voltage standard over the frequency range

CW MAGNETRONS

attuned to new applications

This Litton continuous wave magnetron is one of a family of ten that gives coverage from P to X bands at minimum power outputs from 250-500 watts.

The dependability and versatility of Litton CW magnetrons has been time-proved by the many thousands in field service. There are undoubtedly long years of operation ahead in new military and commercial applications.

These Litton CW magnetrons are mechanically-tuned and liquid-cooled. We also manufacture CW magnetrons with versatile hydraulic tuning and, at lower powers, can supply them with forced air cooling.

Litton CW magnetrons are being applied in a pulse width modulated navigation system. Pulse rate, amplitude and frequency modulation techniques make possible other communication applications. This family also offers many advantages in such CW applications as RF drivers, industrial processing and component testing. They can be pulsed to approximately 2 KW peak power at a .25 duty cycle, a desirable attribute in component testing.

Investigation of these magnetrons and Litton pulse magnetrons, the international standards of excellence, may lead you to new applications. If we have stimulated your thinking a little, we *would* like to hear from you. Write to: 960 Industrial Road, San Carlos, California.

CW MAGNETRONS

Type Number	Frequency Range Megacycles	Minimum Power Watts
L-3456	350-590	500
L-3459	590-975	500
L-3465	975-1500	400
L-3464	1500-2350	400
L-3460	2350-3575	500
L-3461	3575-4975	400
L-3467	4975-6175	400
L-3468	6175-7275	300
L-3462	7275-8775	300
L-3463	8775-10,475	250

LITTON INDUSTRIES
Electron Tube Division
MICROWAVE TUBES AND DISPLAY DEVICES

"Capability that can change your planning"

CIRCLE 119 ON READER SERVICE CARD

ENGINEERING
REPORT
ON BENDIX COMPONENTS

NON-BUFFERED CASCADED RESOLVER CHAINS

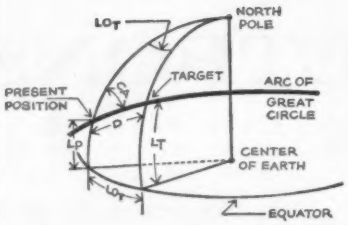
FOR NAVIGATIONAL, GUIDANCE, AND FIRE CONTROL COMPUTERS

Newly-developed techniques enable Eclipse-Pioneer to solve coordinate transformation problems using size 10 (or smaller) resolvers with performance exceeding resolver chains using size 23 resolver and feedback buffer amplifiers.

Our design philosophy is based on the premise that all component parameters will be allowed to fluctuate with variations in excitation voltage, frequency, and ambient conditions. All resultant signal variations can be closely predicted through digital computer analysis.

As a result of Eclipse-Pioneer's experience in utilizing resolver chains in its navigational systems, considerable data has been compiled which may be helpful in solving your problems. Write us today for complete information.

TYPICAL PROBLEM



PROBLEM: Design a computer to provide an aircraft with continuous bearing and range information along the arc of a great circle.

C_A—Bearing

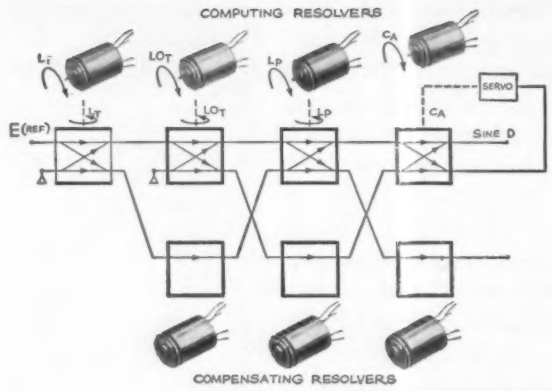
LO_T—△Longitude measured from present position to target

L_P—Latitude of present position

L_T—Latitude of target

D—Great Circle distance from present position to target.

SOLUTION



Eclipse-Pioneer Division
Teterboro, N. J.

The Bendix Corporation

District Offices: Burbank and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D. C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

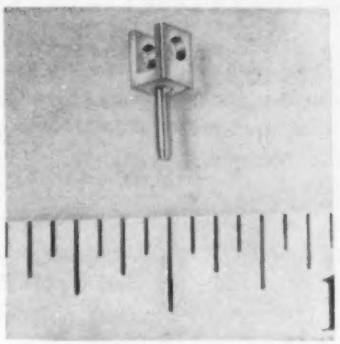
of d-c to 900 Mc is announced by Ballantine Laboratories, Boonton, New Jersey.

Stable, passive circuit elements make the Model 440 Micropotentiometer a practical laboratory standard device for use as a relative voltage standard to measure the frequency response of electronic equipment, or as an absolute voltage reference for precisely calibrating electronic voltmeters, signal generators, and other devices.

Based on designs of the National Bureau of Standards, the unit provides a precisely determined voltage at its output terminal when d-c to 900 Mc current is fed into the input terminal. Output voltage can be varied from one third to full rated output by varying the current through a radial resistor over a three-to-one range. Using various thermocouple-radial resistor combinations, output ranges from 40 microvolts to 0.33 volt can be provided.

For use as a laboratory standard, each unit is calibrated by the National Bureau of Standards over the frequency range of 10 Mc to 1,000 Mc. The basic design and method of production ensures calibration stability.

CIRCLE 307 ON READER SERVICE CARD



Printed Circuit Plug

EDGE MOUNTING

A NEW printed circuit plug has been announced by Cambridge Thermionic Corporation, 445 Concord Avenue, Cambridge 3, Mass. The plug, No. 2850, is primarily designed for use in printed circuits and particularly for edge mounting on $\frac{1}{16}$ and $\frac{3}{32}$-inch printed circuit boards. However, it may also be used for conventional circuits. The end of the shank is slotted to a depth of 0.125 inch and is available

in two slot widths to accommodate the two board thicknesses of $\frac{1}{16}$ and $\frac{1}{8}$ inch. The plug has a pin 0.045 inch in diameter and is approximately $\frac{11}{16}$ inch long. Plug mates with jacks No. 2378 and No. 2650. Material is brass per QQ-B-626a, Comp. 22, $\frac{1}{2}$ hard with 0.0002 inch silver plate plus 0.000020 inch gold flash or 0.0002 inch bright alloy plate.

CIRCLE 308 ON READER SERVICE CARD

Fixed Delay Timer
SOLID STATE

ELGIN MICRONICS, Chatsworth, Calif., is marketing a miniature one cubic inch delay timer weighing 1.4 oz. The compact solid state fixed delay timer is designed to supply a switching function to an external circuit. It has a range of 25 milliseconds to one minute and can be supplied adjustable on request. The timer is temperature compensated with an accuracy of ± 5 percent over the temperature range of − 55 C to + 80 C. Input voltage is 18 to 30 v d-c. Acceleration is 20 g for one minute. The unit is fungus and moisture proof, will operate as specified when mounted in any position, and has minimum life of 100,000 cycles.

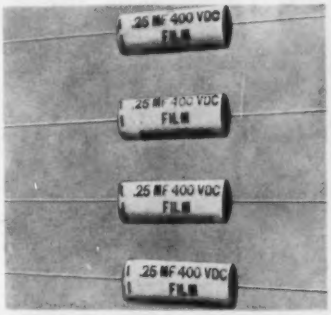
CIRCLE 309 ON READER SERVICE CARD

Capacitor Charger
HIGHLY EFFICIENT

CUBIC CORP., 5575 Kearny Villa Road, San Diego 11, Calif. Model P-1 specialized power supply was designed for high-intensity gas-discharge tubes of the type commonly used in high-speed photography. Housed in an encapsulated container, it is suitable for aircraft, missiles and satellites. It will power the flashing light in a forthcoming goedetic satellite to be launched by the National Space and Aeronautics Agency.

Under varying input loads, the efficiency of the tiny 3-lb unit is 65 percent. It is $2\frac{3}{8}$ in. by 3-in. by $5\frac{3}{4}$ in. in size and will operate in temperatures ranging from −10 C to −60 C. Life expectancy exceeds 10,000 hours.

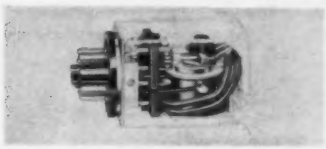
CIRCLE 310 ON READER SERVICE CARD



Capacitors
METALLIZED MYLAR

FILM CAPACITORS, INC., 3400 Park Ave., New York 56, N. Y. New "Flat Wrap" metallized Mylar capacitors offer the ultimate in miniaturization and reliability. Usable temperature range up to 125 C without derating. Self-healing characteristics greatly extend the life of the capacitors. Low dielectric absorption and extremely high insulation resistance are other advantages. Tolerances of 1 percent and better are available upon special order. The units are wrapped in Mylar tape and the ends filled with epoxy resin. This assures excellent resistance to humidity and may be used in potting applications or as is. Ideal for space savings and low cost.

CIRCLE 311 ON READER SERVICE CARD



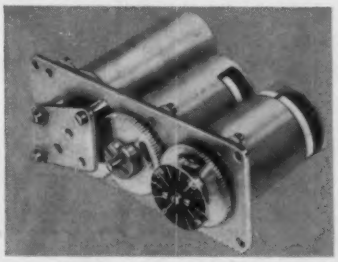
Plug-In Relay
HAS BUILT-IN LAMP

GUARDIAN ELECTRIC MFG. CO., 1550 West Carroll Ave., Chicago 7, Ill.

ENGINEERING
REPORT
ON OTHER BENDIX
COMPONENT PACKAGES

OMNI-BEARING CONVERTER

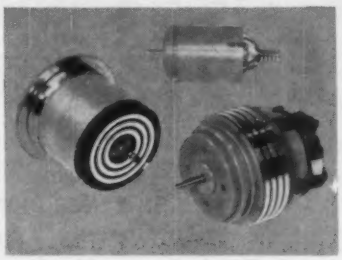
Modular package permits smaller, lighter navigation receiver design



Compass heading and VOR signals are computed and converted by this radio receiver component into signals that position the displays in the Radio Magnetic Indicator of an aircraft radio navigation system. In a package measuring only $3\frac{5}{8}$" x $2\frac{1}{16}$" x $1\frac{1}{2}$", the module comprises a size 11 resolver, differential, motor-generator, gear train assembly and indicator dial. Write today for complete information.

SYNCHRO SLIP RINGS

Autosyn® provides electrical contact with both rotor and stator



In the compact Autosyn design, both housing and shaft can be rotated, permitting introduction of another variable into the system. Electrical contact with both elements is made through external slip rings, which replace the usual fixed leads or terminals. Slip ring location and configuration can be varied to meet specific mechanical or electrical needs. Precious metals are used in the rings to minimize contact resistance and insure maximum reliability. Write for details. ®REG. U.S. PAT. OFF.

Manufacturers of
GYROS • ROTATING COMPONENTS
RADAR DEVICES • INSTRUMENTATION
PACKAGED COMPONENTS
Eclipse-Pioneer Division

THE Bendix CORPORATION
Teterboro, N. J.

A NEW LINE OF
SILICON ZENER DIODES
AND RECTIFIERS

by the ELECTRON DIVISION

SILICON ZENER DIODES: From 150 milliwatts to 50 watts, 3.9 volts to 200 volts. Diodes can be matched in pairs, triplets, and quads. Double anodes available from 1.5 volts to 60 volts. For power units: **anode or cathode grounded optional.** Will meet military specification.

SILICON RECTIFIERS: Up to 12½ amps, 10 to 900 PIV in free air; exceeding 50 amps by forced air cooling and 100 amps by water cooling. Full wave rectifier made to customer's specifications.

Controls Company of America invites your inquiry. High quality and dependable delivery assured. Write or call for catalogs and engineering data.

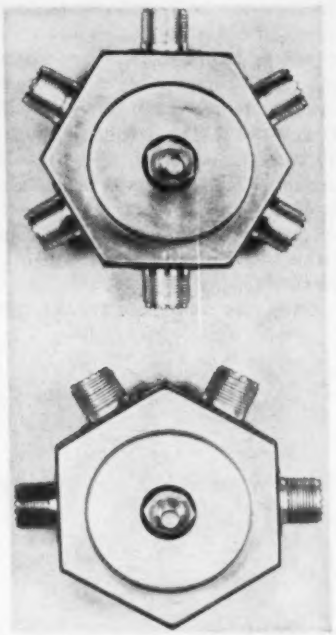
Semiconductor Component Specialists

CONTROLS COMPANY OF AMERICA
ELECTRON DIVISION
811 W. Broadway, P.O. Box 937, Tempe, Arizona

122 **CIRCLE 122 ON READER SERVICE CARD**

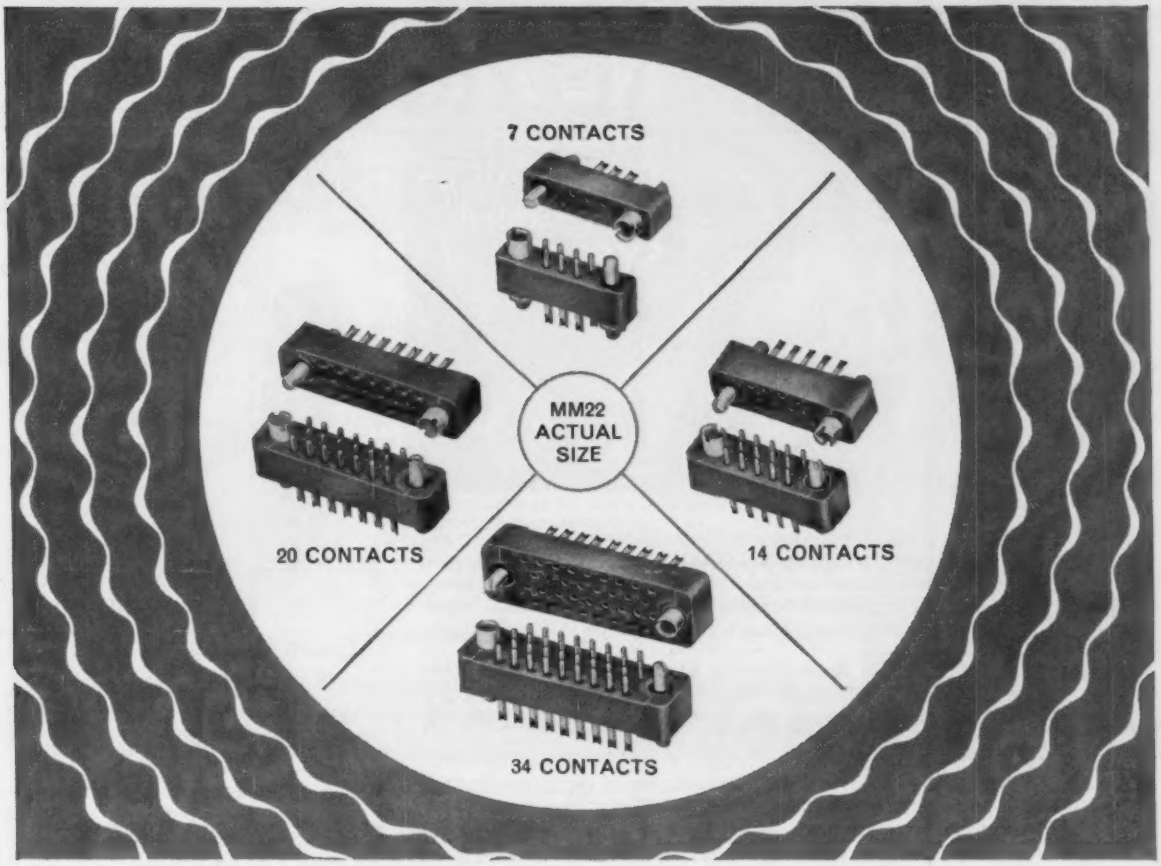
A miniature neon lamp is connected across the coil terminals of the series 1210-N plug-in relay. The lamp lights when coil is energized. Should it remain "dark" with coil energized a circuit fault would be indicated. Unit is currently being used in relay banks, mass relay installations, and wherever relays are visible at intermediate switching points in such circuitry. Principal advantage of the light is that it precludes the use of a circuit tester. Relay is available with 8 pin octal plug for dpdt and 11 pin for 3pdt. Contacts rated 8 amperes at 115 v a-c, 60 cycles, noninductive load. Size, 2 22/32 in. by 1⅞ in. by 1⅞ in.

CIRCLE 315 ON READER SERVICE CARD



Coaxial Switches
MULTIPOSITION

BARKER & WILLIAMSON, INC., Bristol, Pa., announces multiposition coaxial switches designed for radio frequencies to 30 Mc. Model 550A selects any one of five transmitters, antennas, exciters or other equipment and handles up to 1 Kw of modulated power with a maximum crosstalk of — 45 db. Model 551A is a two-pole, two-position unit for switching equipment rapidly in or out of series connection. It is also suitable for switching devices such



THESE 'LITTLE GIANTS' WITHSTAND SHOCK AND VIBRATION

Micro-Miniature Ruggedized Continental Connectors

- Smallest size without sacrificing performance
- Available with 5, 7, 9, 11, 20, 26, 29, 34 and 44 contacts
- Reversed guide pin and socket for positive polarization
- Supplied in various molding compounds
- Available with hoods, screwlocks and shells

Continental Connector's Series MM22 precision micro-miniature connectors simplify interconnection of compact sub-assemblies where space limitations demand the smallest components and highest reliability.

ELECTRICAL AND MECHANICAL RATINGS

Voltage Ratings:	Breakdown	Recommended Test
At Sea Level	2400V. RMS	1600V. RMS
At 70,000 Ft.	650V. RMS	425V. RMS

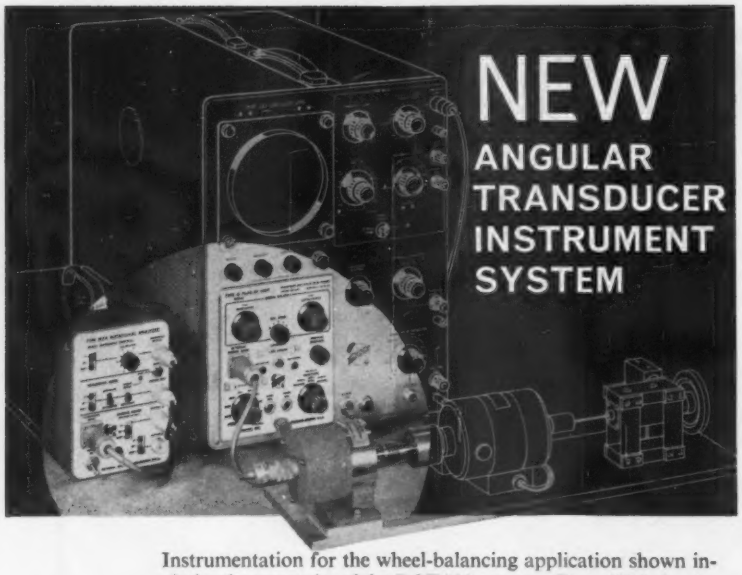
Current Rating	3 Amps
Minimum Creepage Between Contacts	1/16"
Minimum Air Space Between Contacts	.040"
Contacts, Center-to-Center	3/32"
Pin Diameter	.030"
Solder Cup	#22 AWG Wire

Technical data sheets on micro-miniature and other Continental Connectors are available on request. Specify your requirements to Electronic Division, DeJUR-AMSCO Corporation, 45-01 Northern Boulevard, Long Island City 1, N. Y. (Exclusive Sales Agent.)

CONTINENTAL CONNECTORS

MANUFACTURED BY
CONTINENTAL CONNECTOR CORPORATION
AMERICA'S FASTEST GROWING LINE
OF PRECISION CONNECTORS

CIRCLE 123 ON READER SERVICE CARD 123

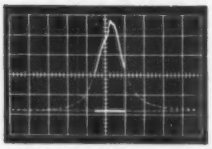


Instrumentation for the wheel-balancing application shown includes the two units of the ROTAN system—Type 182A Angle-Encoding Transducer and Type 183A Rotational Analyzer—working in conjunction with a linear variable differential transformer and a Type Q Plug-In Unit in a Type 533 Oscilloscope.

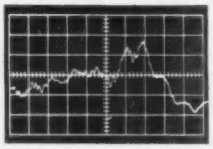
TEKTRONIX®

A Type 182A Angle-Encoding Transducer and a Type 183A Rotational Analyzer comprise the new Tektronix ROTAN system. Designed to study rotation-associated phenomena in machinery, the two ROTAN units adapt an oscilloscope to provide horizontal trace deflection proportional to angular displacement of a rotating shaft. The ROTAN system generates a horizontal sweep representing shaft angle—at speeds from essentially zero to 20,000 rpm. Transduced data, such as velocity, pressure, acceleration, or vibration (applied to the oscilloscope vertical input), appears on the crt screen correctly referenced to this instantaneous angular position.

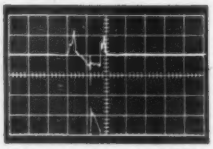
TYPICAL ROTAN DISPLAYS



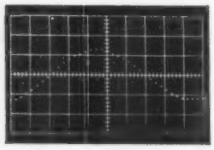
Diesel engine cylinder pressure *vs.* crank angle. 360° display with 10° intensity markers. Intensified portion is the 50° sector covered by the main sweep, starting at 160°.

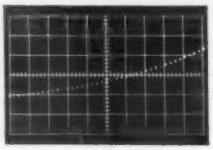


Vibration *vs.* crank angle. 360° display of a 4-cycle, 1-cylinder gasoline engine.



Ignition *vs.* crank angle. 360° display with 10° intensity markers. The upper trace is the secondary voltage and the lower trace is the secondary current.





Bearing housing displacement *vs.* angular shaft position—wheel balancing application. *Left:* a normal trace, 360° rotation of the wheel, 10° intensity markers. *Right:* a magnified trace, 1° intensity markers. Amplitude designates the amount of wheel unbalance. Peak designates the point of unbalance.

Price, ROTAN System, . $850.00
(f.o.b. factory)

Call your Tektronix Engineer for a demonstration of the ROTAN system in your own application.

Tektronix, Inc.

P.O. Box 500 • Beaverton, Oregon • Phone Mitchell 4-0161 • TWX—BEAV 311 • Cable: TEKTRONIX

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TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics, Portland, Oregon • Seattle, Washington. Tektronix is represented in twenty overseas countries by qualified engineering organizations.

In Europe please write Tektronix Inc., Victoria, Ave., St. Sampsons, Guernsey C.I., for the address of the Tektronix Representative in your country.

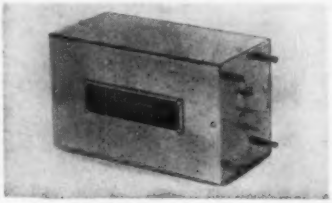
as r-f power amplifiers in or out of circuit. Both switches are designed to be used with 52 or 75 ohm coaxial lines. Diameter across connecting terminals is 4 in., and front-to-back dimension including shaft extension is 3 9/16.

CIRCLE 316 ON READER SERVICE CARD

Console Cabinet
SLOPED FRONT

PREMIER METAL PRODUCTS CO., 337 Manida St., New York 59, N. Y., has added to its line of Prem-O-Rak modular console cabinets for the electronic industry a sloped front unit consisting of a frame and end panels. Designed for custom packaging both singly and for multiple installations. The tops of both front and rear are rounded. The 17½ in. panel space sloped front area is 19 deg from vertical. Front and rear panel mounting angles are adjustable to any desired position. A cutout is provided in the bottom for leads, etc. Holes are punched to accommodate casters.

CIRCLE 317 ON READER SERVICE CARD



Delay Lines
ULTRAFAST RISE TIME

AD-YU ELECTRONICS LAB., INC., 249-259 Terhune Ave., Passaic, N. J., has available a new series of delay lines. Ratio of rise time to total

The Leaders Specify **ALPHLEX®** *ZIPPER TUBING*

ALPHA electronic WIRE

- constant flexibility
- cuts time and labor
- outer jacket is replaceable
- wire changing is simplified
- eliminates costly jacket extrusion
- immediate delivery from your local Alpha distributor

For all these benefits, Alphlex Zipper Tubing is used by such OEM leaders as IBM, IT&T, Librascope, Lockheed, Martin, Sperry Rand and Government agencies. Write for free Alphlex Catalog Z-2.

The new Alphlex Closing Tool (above) designed to save you time, labor and money in your cable production requirements is free with each order of 1,000 feet of Zipper Tubing.

TYPES OF ZIPPER TUBING

ZIP-31	fabricated from .020" polyvinyl sheet made from MIL-I-631C materials. All purpose type for general applications to 105°C. Standard colors: Clear, Black, Yellow.
ZIP-31M	heavy duty construction. Similar to ZIP-31 type except nominal wall thickness of .040". Standard colors: Clear, Black.
ZIP-44	polyvinyl sheet made from MIL-I-7444B materials. Extremely flexible; for aircraft and low-temperature uses to –67°C. Standard colors: Clear (amber), Black.
ZIP-44M	heavy duty construction. Similar to ZIP-44 type except nominal wall thickness of .040". Standard colors: Clear (amber), Black.
ZIP-50	"sandwich" of aluminum foil laminated between two sheets of polyvinyl. For 100% RF shielding applications to 105°C. Standard color: Silver Grey.
ZIP-90	polyvinyl bonded to woven fibreglass sheet per MIL-I-3190A. For rough usage, abrasion resistance, and high temperature uses to 130°C. Standard color: Black.

All types available in inside diameters from ¼" to 2" in increments of ⅛"; and from 2" to 4" in increments of ¼".
Alphlex Zipper Tubing covered by Patents #RE24,613 and #2,558,367 and other patents.

ZIPPER SPECIFICATIONS FOR ALL TYPES OF ALPHLEX ZIPPER TUBING

Material	Polyvinyl Chloride
Track Thickness (when closed)	.065"
Dielectric Strength, V/mil	750
Tensile Strength P.S.I.	3610
Ultimate Elongation	255%
Operating Temperature, Upper Limit	105°C
Cold Brittleness	–65°C
Fungus-proof	will not support fungus
Flammability	self-extinguishing
Lateral Pull Strength (unsealed)	42.7 pounds/inch
Lateral Pull Strength (permanently sealed)	59.8 pounds/inch
Standard Colors	Black, Clear, Yellow

ALPHA WIRE CORPORATION Subsidiary of LORAL Electronics Corporation
200 Varick Street, New York 14, N. Y.
Pacific Division: 1871 So. Orange Dr., Los Angeles 19, Calif.

ALPHA electronic WIRE

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New e-x-p-a-n-d-e-d production facilities now give you ACE PRECISION on all types of screw machine centerless ground parts and special shapes . . . all colors . . . all materials.

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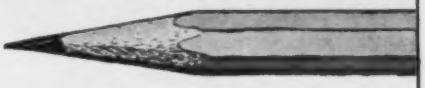
CIRCLE 203 ON READER SERVICE CARD

SEYMOUR STAINLESS STEEL



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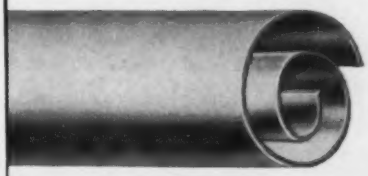

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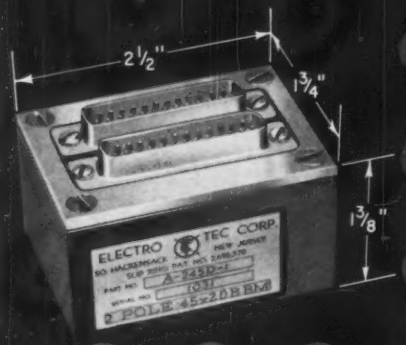
CIRCLE 125 ON READER SERVICE CARD

A SIGNAL ACHIEVEMENT IN TELEMETRY... ELECTRO-TEC'S NEW 450-CIRCUIT COMMUTATING SWITCH



Electro-Tec's new compact 8-oz. motor driven telemetering switch enables circuit combinations up to a maximum of 5 poles, 90 channels per pole . . . truly the answer to precision performance with optimum size and weight.

Specifically developed for satellite and missile use, the ETC switch incorporates unique engineering ideas extending its utility to a variety of other military and industrial applications. Exclusive microminiature design minimizes brush velocity. Precious metal contact surfaces assure lowest levels of noise and resistance. Hermetically-sealed connectors add to environmental protection. These and other features provide a life expectancy of well beyond 1000 hours.

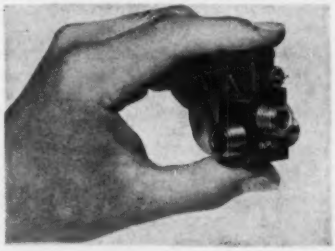
Write for new ETC switch brochure.

ELECTRO-TEC CORP. Administrative and Executive Offices: 10 Romanelli Avenue, South Hackensack, N. J. Manufacturing Plants: Blacksburg, Va.—Ormond Beach, Fla.

PATENT NUMBER 2,696,570 AND OTHERS PENDING.

delay can be less than 1.5 percent, yet the attenuation is less than 0.1 db per millisecond delay. Extremely stable, temperature coefficient less than 0.01 percent per deg C. Saturation level is above 150 v. A great deal of circuitries and improvement can be secured by using these lines in computers, radar systems, control devices, etc. Embedding in resin compound can be provided to afford maximum protection from shock, vibration and humidity. The lower limit of frequency response is down to d-c.

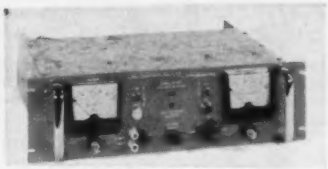
CIRCLE 318 ON READER SERVICE CARD



Coaxial Switch
FOR AIRBORNE USES

DON-LAN ELECTRONICS INC., 1131 Olympic Blvd., Santa Monica, Calif., is manufacturing a coaxial switch which will withstand 50 g sustained acceleration and 20 g vibration from 75 to 2000 cps. It has been developed for missile and other airborne applications. The switches feature extreme miniaturization with a weight of only 75 grams, and a switching time of 0.006 sec. The spdt "fail safe" units are available for 6 to 30 v d-c and 15 v 400 cycle a-c operation with TNC, N or HN coaxial connectors in an r-f frequency range of 100 to 5,000 Mc.

CIRCLE 319 ON READER SERVICE CARD



Power Supply
RACK MOUNT

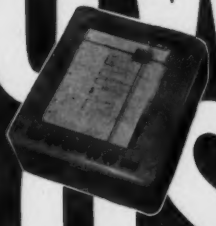
TRANS ELECTRONICS, INC., 7349 Canoga Ave., Canoga Park, Calif., an-

X-Y RECORDER

Model HR-92

Unconditionally Guaranteed For One Year

LOW COST



Rugged, simple (8½"x11") plotter contains all essential features for 95% of all X-Y applications. Basic Model HR-92-1 is $595.00 (USA) with 10mv/in. sensitivity, ½% accuracy.

Write for bulletin 792-4.

houston instrument corporation

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DIAMOND WHEELS

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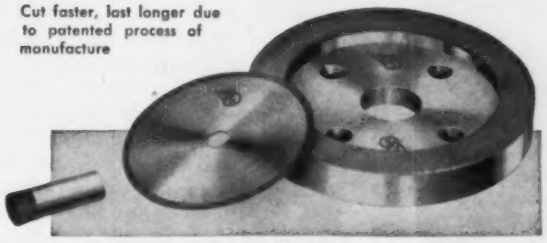

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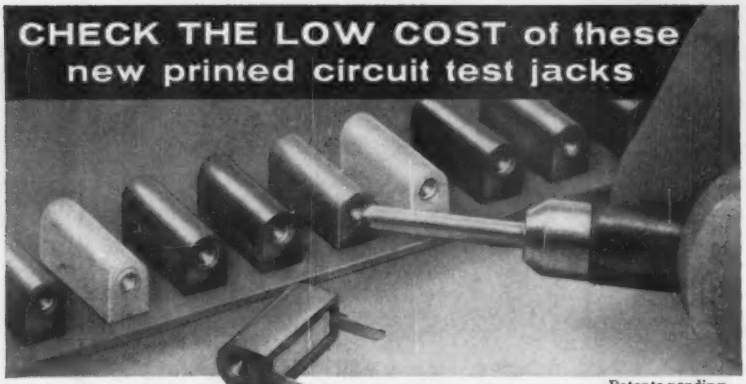
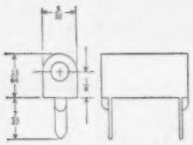


WESCON Booth 2606

Patents pending



For .052 application holes on .400 centers

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ELECTRICAL DOT ASSEMBLIES

The UCINITE COMPANY
Division of UNITED-CARR Fastener Corporation
Newtonville 60, Massachusetts

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rese RE engineering, inc.
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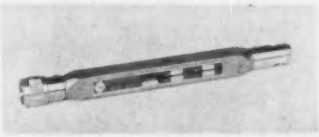
nounces a new rack mount regulated power supply. Output for model RR550 is 300-500 v d-c at 0-500 ma. Input 105-125 v a-c 55-400 cps. Line regulation 0.1 percent; load regulation 0.1 percent; ripple and noise, 1.5 mv rms max.; filament output 6.3 v CT at 15 amperes; polarity either positive or negative may be grounded; output superior binding posts on front panel; barrier strip on rear. Panel includes: a-c and d-c output terminals, a-c power on-off switch and pilot light, d-c output on-off switch and pilot light, voltage range selector, voltage vernier control. Without meters the unit is priced at $310; with meters, $350.

CIRCLE 320 ON READER SERVICE CARD



Fixed Attenuators
MICROWAVE

FXR, INC., 25-26 50th St., Woodside 77, N. Y. Series 180 fixed coaxial attenuators feature exceptional stability and are capable of withstanding appreciable overloads and peak powers with no change of characteristics. Shock and vibration resistance is high and a negligible change of attenuation occurs under humidity and temperature cycling. Nominal attenuation for the series is 3, 6, 10 and 20 db. Frequency range is 1,000 to 12,400 Mc for 3, 6 and 10 db and 2,000 to 12,400 Mc for 20 db. Impedance is 50 ohms. Temperature coefficient of attenuation is 0.00043/db/deg F, from 32 F to 125 F. Insertion length, approximately 7¾ in. Price, $42.

CIRCLE 321 ON READER SERVICE CARD

Silicon Transistor
SYMMETRICAL UNIT

CRYSTALONICS INC., 249 Fifth St., Cambridge 42, Mass., announces an improved symmetrical silicon transistor designated C106. It features a minimum beta of 30 in both directions and a maximum saturation resistance of 5 ohms at 10 ma collector current. Unit is recom-

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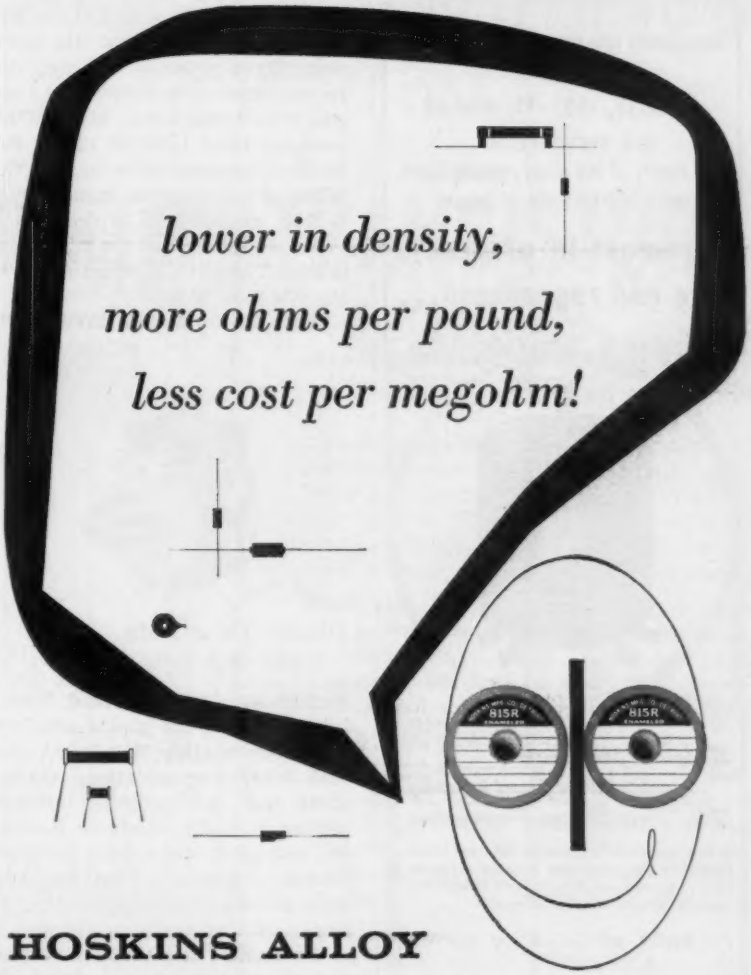
Panel Voltmeter
HIGH ACCURACY

VOLTRON PRODUCTS, INC., 1020 So. Arroyo Parkway, Pasadena, Calif., can now furnish panel voltmeters with an accuracy of 0.1 percent for either a-c or d-c applications. This new degree of accuracy is made possible by a combination of a taut band meter movement and an extremely precise expansion network. Use of a taut band meter movement is said to eliminate completely the static friction found in conventional pivot and jewel type meters, and provides an extremely rugged construction. Meter maintains its 0.1 percent accuracy in any position and can be used with either a magnetic or non-magnetic panel. Price: d-c, $200; a-c $230.

CIRCLE 323 ON READER SERVICE CARD

Harmonic Mixers
FIXED TUNED

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif., has two new fixed tuned harmonic mixers which speed and simplify frequency measurements up to 18,000 Mc. Model P932A, operating in the 12,400 to 18,000 Mc P-band, mounts directly in a waveguide system and operates with a H-P model 540A or



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815-R Precision Resistor Wire

12.8 to 14.1% more ohms per pound! 10.8 to 12.7% less cost per megohm! These are worthwhile savings you can realize by using Hoskins Alloy 815-R in your precision wire-wound resistors. It's lower in density, has higher resistivity than standard 800-ohm nickel-chromium alloys. Yet it possesses comparable strength, ductility, resistance to corrosion. Its low temperature coefficient (0 ±10ppm per °C. from −65° to +150°C.)* is inherently controlled in the melt, rather than by "aging", to assure optimum uniformity. And it's available now bare or enameled in wire sizes ranging from .0031" down to and including .0004" to meet your particular application requirements.

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**Wire controlled to 0 ± 20ppm/°C. also available at greater savings—up to 19.6% lower cost/megohm.*

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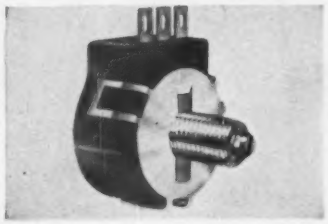
540B transfer oscillator. Its maximum input power is 100 mw, and its minimum video output is 0.1 mv rms with 0 dbm input. Model 934A operates from 1,000 to 12,400 Mc. It offers the same advantages as the 932A. Its maximum input power is 100 mw, and its typical sensitivity is −45 dbm at the mid-range points. The 932A is priced at $250; the 934A, at $150.

CIRCLE 324 ON READER SERVICE CARD



Plastic Case Pots
MEET MIL SPECS

WATERS MFG., INC., Wayland, Mass., introduces a ⅜ in. plastic case pot completely meeting MIL-R-19A and MIL-R-19/1A specifications. O-ring shaft seal and complete internal sealing virtually eliminate humidity, salt spray and similar environmental problems. Provides the same protection as encapsulation in less space. Resistance range (ohms) ± 5 percent, 1 to 20,000. Electrical and functional rotation, 355 deg without stops; 300 deg with stops. Dissipates 1.5 w at 40 C. Torque, 0.3 to 6 oz/in. Weight, 0.02 lb. Available with split bushings or plain bushings, ¼ in. or ⅜ in. in diameter.

CIRCLE 325 ON READER SERVICE CARD

Damping Diode
FOR TV RECEIVERS

WESTINGHOUSE ELECTRIC CORP., P. O. Box 284, Elmira, N. Y. Type 6CQ4 damping diode, for use in hori-

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The relatively low base resistance and collector capacitance and the high gain bandwidth products that characterize SYLVANIA DRIFT TRANSISTORS make them especially well-suited to high-speed switching service in electronic computer applications.

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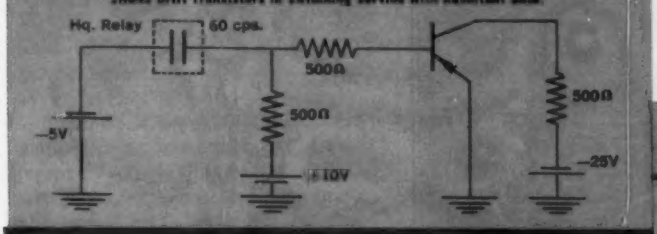
Prices and delivery information are available now at your local Sylvania Field Office *or* your local Sylvania franchised Semiconductor Distributor. For technical data write Semiconductor Division, Sylvania Electric Products Inc., Dept. 229, Woburn, Mass.

Test Circuit for Evaluating Performance of Sylvania 2N604 and 2N645 Drift Transistors in Switching Service with Resultant Data.



Characteristics	Time in mμSec.
Delay time t_d	30-40
Rise time t_r*	10-20
Storage time t_s	120-380
Fall time t_f*	10-20
Turn on (typical)	60
Turn off (typical)	260

*Estimated – rise time and fall time observed in same order as rise time of 'scope.

OUTSTANDING FEATURES OF KEY SYLVANIA DRIFT TRANSISTORS

2N602	10 Mc (min.) gain bandwidth product
2N603	30 Mc (min.) gain bandwidth product
2N604	50 Mc (min.) gain bandwidth product
2N624	30 db pwr gain (min.) at 12.5 Mc. Meets all requirements of MIL-T-19500/82 (SigCorps)
2N643	20 Mc (min.) gain bandwidth product
2N644	40 Mc (min.) gain bandwidth product
2N645	60 Mc (min.) gain bandwidth product
2N1224	17 db pwr gain (min.) at 12.5 Mc
2N1225	15 db pwr gain (min.) at 50 Mc
2N1226	60 Volts V_{cb} version of 2N1224

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LET'S PLUG

FOR BETTER TESTING WITH EECo'S TEST SOCKETS

Now all header-terminal components automatically become plug-in devices for test and evaluation, when you test solder-terminal relays, transformers, crystal cans, etc., with the new EECo universal test socket series.

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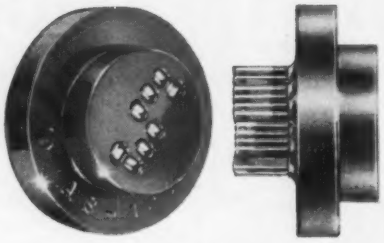

AS-Series Test Sockets

EECo RT-905 RELAY TESTER for faster, more accurate testing. Measures voltage and current simultaneously, both pull-in and drop-out time, contact bounce. Automatic relay driving circuitry. Oscilloscope connections and circuitry.

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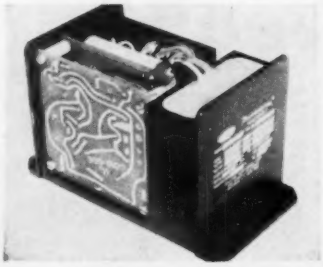
College Point, L.I., N.Y.

CIRCLE 209 ON READER SERVICE CARD

zontal deflection circuits of tv receivers, is rated at 5,500 v (peak) and 190 ma (average plate current). Plate dissipation is conservatively rated at 6.5 w. Low tube drop (25 v at 250 ma) permits use of the 6CQ4 both in low B-plus and wide-deflection-angle circuits. The heater is rated at 6.3 v and 1.6 amperes. Design features contributing to the tube's high ratings are: a glass-ring plate suspension which eliminates mica arc over; a mechanically anchored spiral insulator between heater and cathode which permits higher heater-to-cathode voltage ratings than conventional cemented assemblies; and a new h-v tube base in which base pins are mounted in wells to increase between-pin insulation.

CIRCLE 326 ON READER SERVICE CARD



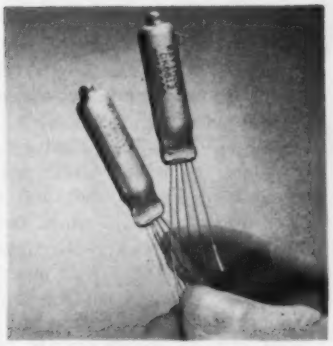
Converter Series

SOLID STATE

SPECTROL ELECTRONICS CORP., 1704 South Del Mar Ave., San Gabriel, Calif., has available a series of transistorized converters utilizing printed circuitry. The Transidyne converters are static type power sources designed to replace motor generator and vibrator type devices for the conversion of d-c input voltages to d-c outputs of different voltage levels. There are 15 standard models in the 763 series, varying in output voltage from 10 to 150 v d-c with a nominal 28 v d-c input. Size is 2¾ in. wide by 3 in. high by 5 in. long overall. A protected screwdriver adjustment allows ± 5 percent output voltage adjustment. Other standard specifications: maximum output power, 75 w; maximum output current, 4.0 amperes; maximum ripple, 20 mv rms; regulation, 0.1 percent; maximum weight, 2 lb; operating temperatures, — 55 C to + 71 C. Price for

single units is approximately $300 depending on model.

CIRCLE 327 ON READER SERVICE CARD



R-F Amplifier Tubes
SUBMINIATURE

RAYTHEON CO., 55 Chapel St., Newton, Mass. Two subminiature pentode r-f amplifier tubes feature very high transconductance with low heater power. The CK6611 has a mutual conductance of 1,000 μmhos at a filament power of only 25 mw (20 ma at 1.25 v). The CK6612 has a mutual conductance of 3,000 μmhos at a filament power of only 100 mw (80 ma at 1.25 v). Both have a maximum d-c plate voltage of 30. Using a multiple strand, high-temperature filament instead of a single filament, the tubes have an operating lifetime of more than 5,000 hr. A combination of high input impedance, low grid current, decreased size and weight, plus an integral metallic silver shield, make them ideal for all types of portable communications devices. Each measures only 1.5 in. by 0.285 in.

CIRCLE 328 ON READER SERVICE CARD

Capacitors
METALLIZED PAPER

ELECTRON PRODUCTS, 430 North Halstead St., Pasadena, Calif., announces production of new ME and WE series, subminiature, metal-

TOMORROW'S
CONTROL
DEVICE
AVAILABLE
NOW!
Optimum design for practically any power control application from watts to kilowatts! Miniature, all-semiconductor SCR servo amplifiers* developed by General Electronic Control, Inc. now make it possible!
Thousands of different control amplifiers for applications requiring rapid, precise proportionate control! Individual circuit modules are light, small and easy to combine. New Silicon Controlled Rectifiers (SCR's) make units versatile, efficient.
Modules meet military shock, vibration and environmental requirements—are particularly suited for use in ground support equipment, rockets, missiles, telemetry and other 400 cycle applications requiring high reliability.
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For Bulletin 6067 giving advance technical information write, wire or phone to G.E.C., Application Engineering Department.
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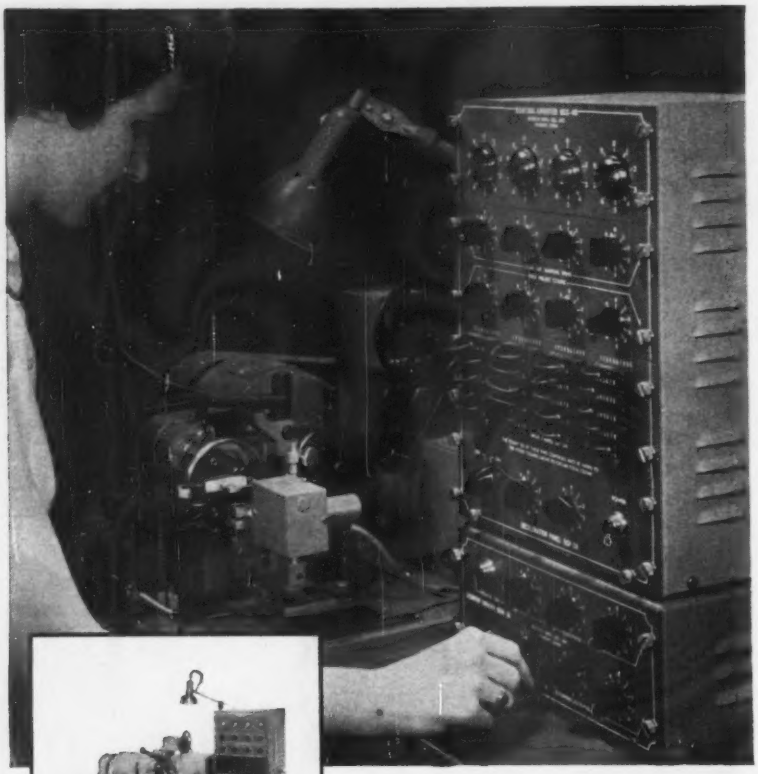
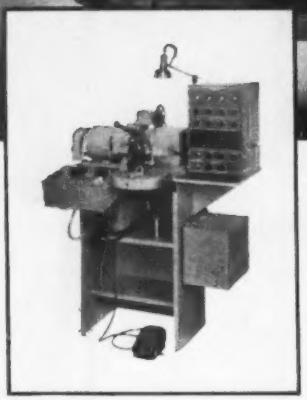
CIRCLE 135 ON READER SERVICE CARD





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electronically controlled toroidal winder

- *speeds up to 2000 turns per minute*
- *4-digit, 2- or 7- position predetermined counting*

The entirely NEW electronic system of the TW 300 provides unmatched features in a toroidal winder . . . proximity pick-up for use with any size wire without physical contact . . . 100% accurate turns counting . . . controlled slow-start, slow-stop driving motor . . . automatic segmental winding with perfect repeatability . . . progressive winding of segments or continuous coils in either direction.

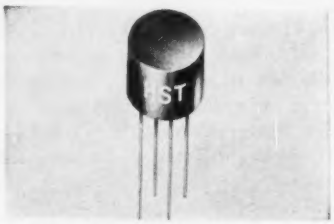
The TW 300, designed for easy servicing and maintenance, cuts production time and operator fatigue to the bone. Flexibility in production of new coil types with superior electrical characteristics is unlimited because of the new control system with automatic winding features. This machine is a significant advance toward complete automation of toroidal winding.

WRITE FOR COMPLETE DATA

BOESCH MANUFACTURING COMPANY, INCORPORATED
DANBURY, CONNECTICUT

lized paper capacitors. Series ME, designed for use in d-c circuitry, are vacuum epoxy-impregnated and sealed in epoxy case. Operating temperature is −55 to + 125 C. Capacitance values are from 0.001 to 2.0 μf. Series WE, for use in a-c or d-c circuits, are vacuum wax-impregnated and have an operating temperature range of − 55 to + 85 C. Capacitance values are from 0.001 to 1.5 μf. Both series are available in 100, 200, 400 and 600 vdcw ratings. Standard tolerance is ± 20 percent with tighter tolerances to order. Units meet or exceed most military environmental specifications.

CIRCLE 329 ON READER SERVICE CARD



Transformers
MINIATURIZED

ARCO ELECTRONICS INC., 64 White St., New York 13, N. Y. New line of miniaturized aTTom transistor transformers (type TT) consists of 47 standard values. They are molded for conformance with MIL-T-27A, Grade 5, Class R for altitudes up to 50,000 ft. Units have excellent response load distortion and very high power capabilities. Valuable chassis space is not taken up with bulky clamps. One inch long hard drawn copper-tinned leads allow for direct printed circuit mounting. Designs cover practically all applications: interstage, output, input, single or push-pull output, reactors, line to base, collector to base or line, collector to speaker, and reversible-input to secondary.

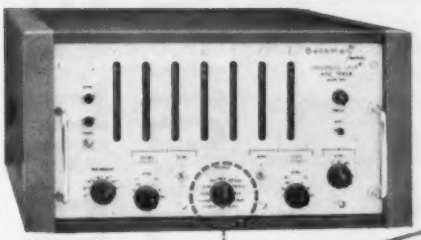
CIRCLE 330 ON READER SERVICE CARD

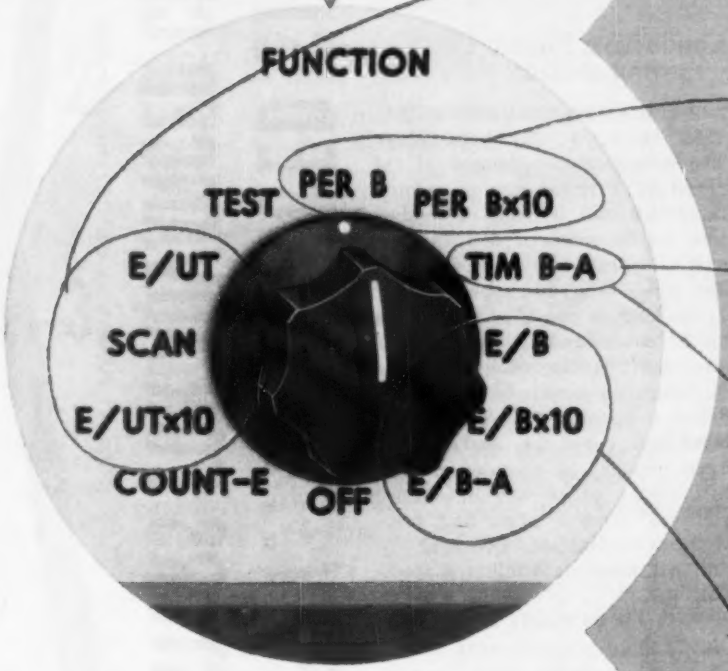
Triode Oscillator
FOR C-BAND

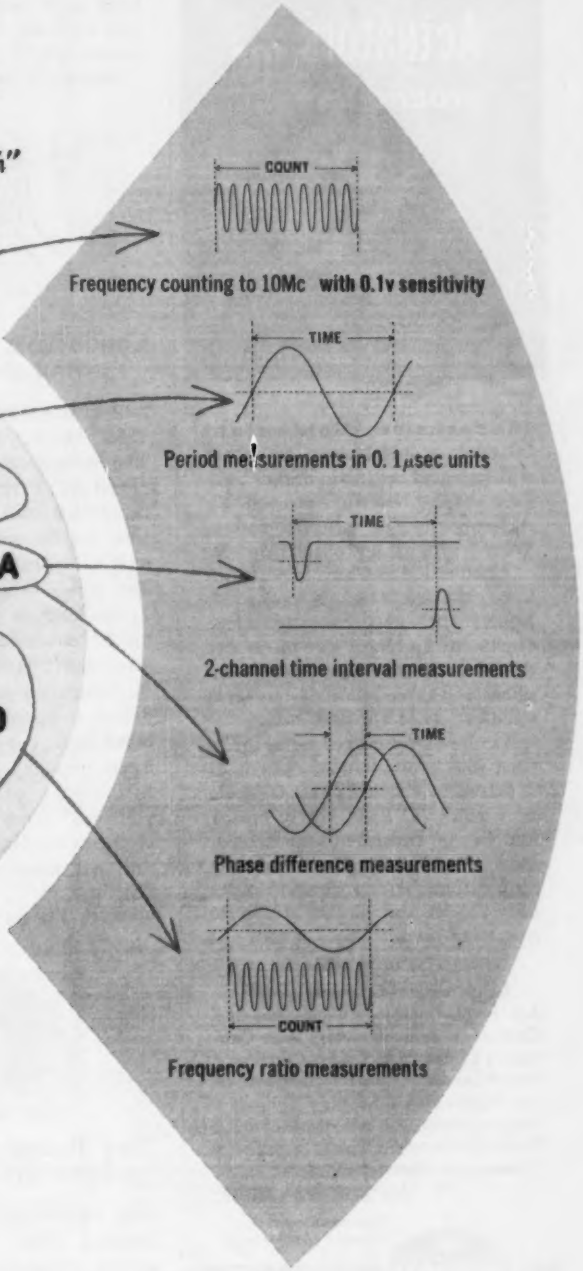
JOHN GOMBOS CO., INC., Webro Road, Clifton, N. J. Model 101C is continuously tunable in 500 Mc steps from 4,200 Mc to 6,000 Mc, is only 9 oz in weight, offers stability at 20

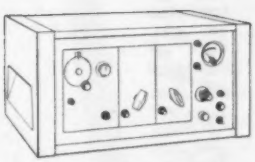
10 Mc COUNTER

does everything without plug-ins

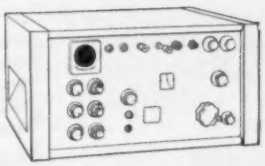








Add this heterodyne unit (Model 7570 Series) to measure frequencies up to 1000Mc.



Or add this computing transfer oscillator (Model 7580) to get a counter display of frequencies up to 15,000Mc.

Complete specifications on Models 7370, 7570 and 7580 will be sent on request.

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T21

COMPACT AiResearch 60 cycle Actuators *for ground use . . .*

Inexpensive, lightweight 60 cycle motor driven actuators with integral magnetic brakes* are now being manufactured by AiResearch for ground radar, ground support and shipboard use.

Unequalled in 60 cycle performance, these extremely compact, lightweight actuators range from fractional hp motor size up to any desired hp in single phase, two phase and three phase design for a wide variety of applications.

The above-pictured actuator is used in a ground radar system. It is driven by a single phase 60 cycle ac fractional hp electric motor and can be furnished with a feedback potentiometer for use in servo applications. The entire unit weighs only 2½ lb. and is rated at 200 lb. operating load.

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Your inquiries are invited.

* *patented 60 cycle operated magnetic brake*

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

g's, and simplifies power problems since only a plate voltage of 175 v and 6.3 v for filaments are required. This oscillator serves as a general purpose member of a family of oscillators designed around the General Electric GL-5139 ceramic triode. Model 101C has applications as local oscillators, c-w signal sources and drivers for crystal harmonic generators.

CIRCLE 331 ON READER SERVICE CARD

Conductive Plastic Pot
LINEAR MOTION

NEW ENGLAND INSTRUMENT CO., INC., 1334 Main St., Waltham, Mass. The potentiometer element of the model 34LP linear motion, infinite resolution unit is made of conductive plastic material allowing the unit to operate in excess of 25 million cycles. The case, approximately 1¾ in. long, is constructed of black anodized aluminum; the stainless steel shaft is supported on bronze bushings at each end. Standard design is supplied with Teflon insulated leads coded for identification. Terminals can be mounted on case by special order and resistance values of from 50 ohms to 1 megohm can be supplied. This long life unit will meet rigid military specifications.

CIRCLE 332 ON READER SERVICE CARD

Tiny Power Resistor
MEETS MIL-R-18546B

DALE PRODUCTS, INC., Box 136, Columbus, Neb. Type RH-5 wire wound, precision power resistor is specifically designed to meet problems where power and heat dissipation problems are complicated by miniaturization requirements. The 5-watt resistor, which is sealed in

From PSI . . . ADVANCED SILICON MESA TRANSISTORS FOR ADVANCED CIRCUIT DESIGN

Send for 1000 mc one watt generator data

1. THE FASTEST 2N697 AVAILABLE!

Nearly half the collector saturation voltage . . . half the leakage current . . . half the collector capacitance . . . 40% greater power dissipation!

COMPARE THESE OUTSTANDING FEATURES OF THE PSI 2N697!

Nine out of ten PSI type 2N697 transistors meet these premium specifications. Guaranteed 100% shipment to the higher specifications will be made when the buyer specifies PSI type PT 822 premium grade.

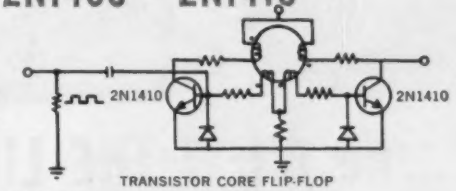
Many of these "plus characteristics" are also featured in the PSI 2N696 . . . ideally suited for the designer not requiring the high gain performance of the PT822.

MAXIMUM RATINGS

PARAMETER	REGISTERED SPECIFICATION	PSI PREMIUM SPECIFICATION	UNIT	TEST CONDITION	% IMPROVEMENT
V_{CER}	40	50	Volts	$R_{BE} = 10\Omega$	25% Higher
V_{CBO}	60	80	Volts	$I_{CBO} = 100\ \mu A$	33% Higher
V_{EBO}	5	8	Volts	$I_{EBO} = 100\ \mu A$	60% Higher
Power Dissipation	2	2.8	Watts	25°C Case Temp	40% Higher
Power Dissipation	0.6	0.8	Watts	25°C Ambient Temp	33% Higher
I_{CBO}	1.0 100	0.5 50	μA μA	$V_{CB} = 30V, T = 25°C$ $V_{CB} = 30V, T = 150°C$	50% Decrease
$V_{BE}(SAT)$	1.3	1.3	Volts	$I_C = 150mA, I_B = 15mA$	————
$V_{CE}(SAT)$	1.5	0.8	Volts	$I_C = 150mA, I_B = 15mA$	47% Decrease
h_{FE}	40-120	40-120	——	$V_{CE} = 10V, I_C = 150mA$	————
h_{fe}	2.5 min	7.0 min	——	$V_{CE} = 10V, I_C = 50\ mA$ $f = 20mc$	280% Increase
C_{ob}	35	18	$\mu\mu f$	$V_{CB} = 10V, I_E = 0$ $f = 140\ kc$	48% Decrease

2. HIGH SPEED SWITCH TYPES – 2N1409 – 2N1410

Typical switching speed of 52 nanosec turn-on time and 130 nanosec turn-off . . . saturation resistance of only 5 ohms and power ratings of 2.8 watts (25°C case temp.) For use in low current logic or high current core-driver circuitry.

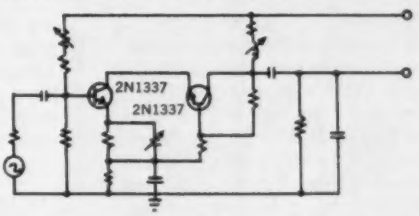


TRANSISTOR CORE FLIP-FLOP

3. HIGH VERSATILITY TYPES – 2N1335 thru 2N1341

The higher power dissipation, faster rise time and lower collector capacitance of the 2N1337, for example, makes this transistor an unusually fine performer in advanced video amplifier circuits.

These 2.8 watt, 120 volt VHF transistors are well suited to IF and DC amplifiers, RF power amplifiers and oscillators and to high voltage switching applications.

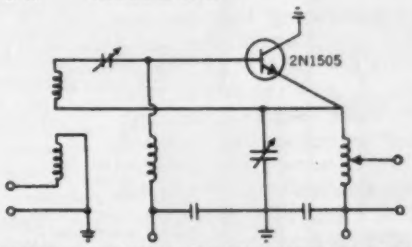


TEN MC BANDWIDTH, HIGH VOLTAGE VIDEO AMPLIFIER

4. COMMUNICATION TYPES – 2N1505 – 2N1506

This series of silicon mesa transistors provides high power output at Very High Frequencies. Typical power outputs are one-half watt at 200 mc with 3 db gain or one watt at 70 mc with 12 db power gain operating from 28V source.

A power output of 2.5 watts at 250 mc. may be obtained by using these transistors with a High-Q Varicap® frequency multiplier.



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Pacific Semiconductors, Inc.

A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.

12955 CHADRON AVENUE • HAWTHORNE, CALIFORNIA

. . . he DREW THE LINE at 1MC!

The most difficult task facing an engineering executive is to strike a **sensible compromise** between the ambitions of his development staff and the needs of the market. No one knows that better than Dan Mindheim, President of TSI. Twelve years of product development (including nine major patents) give him the designer's point of view — but ten years of management experience temper that attitude.

In determining the specifications for our Model 361 **solid-state** APTI®-METER,* for example, he drew the line at 1MC. "95% of all counter-timer applications fall below 1MC," he said. "Let's concentrate on optimizing **flexibility, reliability,** and **portability.** That's what engineers want—at a **sensible** price."

Dan was right. The 361 is selling like . . . well, like **the world's best solid-state 1MC Counter-Timer,** which it is. Frankly, we're hard-pressed to maintain 30-day delivery. The same for its 3½" rack twin, the 361-R.

Care to add to our production headaches? Send for the APTI®-METER bulletin. Buy a few — our development group will forgive you.

**APTI®-METER is our registered trade-mark for an ACTIONS-PER-TIME-INTERVAL meter. Model 361 counts from 0-1MC, has 0.3ppm/week stability, IN-LINE NIXIE READOUT, and identical-twin, high-impedance, high sensitivity amplifiers. Unbelievable versatility, light as a feather, tiny, yet the sensible-compromise price is only $1645.*

TSI

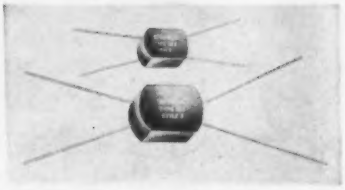
TRANSISTOR SPECIALTIES
INCORPORATED
Sophisticated Digital Instrumentation

TERMINAL DRIVE, PLAINVIEW, NEW YORK • WELLS 5-8700

140 CIRCLE 140 ON READER SERVICE CARD

silicone and inserted in a radiator finned aluminum housing is impervious to moisture and salt spray. It measures 0.600 by 0.0334 in.; has a resistance range from 0.5 ohm to 20 K ohms. Tolerance range is 0.05 percent, 0.1 percent, 0.25 percent, 0.5 percent, 1 percent and 3 percent, Temperature coefficient is 0.00002/deg C. Maximum operating temperature is 275 C. When mounted on a heat sink, it is rated at full power up to 100 C, derating to 0 at 275 C. Free air rating is full power up to 25 C, derating to 0 at 275 C.

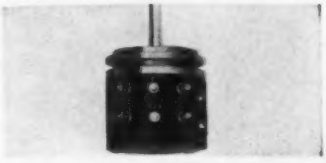
CIRCLE 333 ON READER SERVICE CARD



Pulse Transformers
PRE-MOLDED CASE

SPRAGUE ELECTRIC CO., 35 Marshall St., North Adams, Mass. "Slabbed" circle cases for pulse transformers have been specifically designed for ease of manufacture in the new type 32Z pulse transformer series. The pre-molded shell offers a means of anchoring leads and quickly inserting transformer windings, soldering the external leads to the ends of the windings, and pouring the encapsulating material so that sample transformers for breadboard circuitry are produced quickly and economically. Later, more compact designs in other shapes can be developed for the finished equipment subassemblies.

CIRCLE 334 ON READER SERVICE CARD

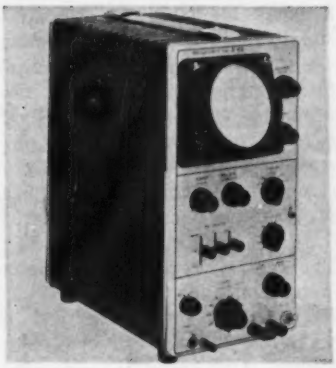


Wirewound Pots
GANGABLE

DAYSTROM, INC., Pacific Division, 9320 Lincoln Blvd., Los Angeles 45, Calif. The 319 series of miniature

wirewound gangable potentiometers are but ⅞ in. in diameter and less than ¼ in. high per ganged section. They are now available in stainless steel (servo) or aluminum (panel) versions and are gangable within a resistance range of 100 ohms to 200 K ohms. The problems of phasing are solved by a unique adjustment method that positions each wiper independently throughout a full 360 deg. Rugged, molded high-temperature plastic cups with metallic details provide great mechanical strength under environmental extremes. Because no clamping rings are needed for ganging these units, the 319 series are said to provide substantially increased stability over conventional pot designs.

CIRCLE 335 ON READER SERVICE CARD



Portable Scope
HIGH WRITING SPEED

THE SCOPES CO., INC., P. O. Box 56, Monsey, N. Y. Model S42 uses a new 4 in. crt with extremely fine focus. Operating at 3.7 Kv, brightness is such that a 1 μsec "single shot" pulse can be seen and photographed. Balanced low-drift amplifiers have bandwidth of d-c to 6 Mc up to 100 mv/cm and a high gain facility gives 10 mv/cm sensitivity with bandwidth limited to 500 Kc. Features include time and voltage calibration with built-in squarewave calibrator, automatic sync and selective triggering, 9-position frequency compensated attenuator and 18 speed time base with X 10 expansion giving maximum speed of 0.1 μsec/cm. Unit's high writing speed and accurate calibration make it especially suitable for design and maintenance work on computers and

THIRTEEN INDISPENSABLE CHARACTERISTICS FOR *Precision* SERVO POTS

PRECISION SERVO POTENTIOMETERS HAVE ALL 13 FEATURES

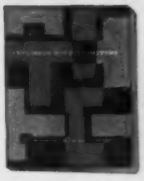
Your Assurance of Superior System Performance

1 High Reliability
2 Low Torque
3 High Accuracy
4 Low Inertia
5 High Resolution (or Infinite in Film Type)
6 Wide Resistance Range
7 Low Phase Shift Over Wide Frequency Range
8 Low Noise Level
9 Highly Precise Non-Linear Functions
10 Can Be Ganged
11 Long Life
12 Close Mechanical Tolerances
13 Withstand Extreme Environmental Conditions

A few of the many applications of TIC Precision Servo Potentiometers are as input-output transducers in servo systems for airborne navigation and flight control, fire control, fuel control, shipboard gun directors, missile aiming and flight control, analog computing, air traffic control and telemetering.

TIC Precision Servo Potentiometers are available in 21 types with diameters from ½" to 3", giving design engineers a wide range from which to select. Included are single and multi-turn types with either wirewound or infinite resolution metallic film resistance elements, as well as types designed for ganging without a shaft. And TIC Precision Servo Potentiometers are engineered to withstand the severe environmental conditions imposed by military equipment operation.

Write or call for this new catalog on the TIC line of Precision Potentiometers - the most complete line on the market.



Type MFR — encapsulated contact patented Metifilm, ultra-reliable, long-life potentiometers

PVR05

PVR05 (ganged)

PVR15

Type PVR — new, complete line of low torque high accuracy, performance proved, servo type precision potentiometers

M10T09

Type M10T09 — multi-turn (3, 5, 10 turn) highly accurate precision potentiometers

C10-09 (ganged)

Type C10-09 — 10 turn, may be ganged

RVBC2

Type RVBC2 — unitized construction for development work

P114

Type P 1¼ — low cost commercial grade, precision potentiometers

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569 MAIN STREET, ACTON, MASS.

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TECHNOLOGY INSTRUMENT CORP. OF CALIFORNIA, NEWBURY PARK, CALIF.

actual size

BRISTOL chopper helps put Navy TARTAR on target

. . . **Every component** in the U.S. Navy's TARTAR, newest supersonic surface-to-air guided missile must meet the highest standards for statistical reliability.

No exception is the Bristol Syncroverter* chopper used in the TARTAR's guidance system. The TARTAR, produced for the Bureau of Naval Weapons by Convair (Pomona) Division of General Dynamics Corporation, is slated to form the primary antiaircraft weapon aboard destroyers and secondary antiaircraft batteries aboard cruisers.

The Bristol Syncroverter chopper has a long history as a component in U.S. guided missiles. It's the ideal miniature electromechanical chopper for use in d-c analog computers or wherever utmost reliability is required.

BILLIONS OF OPERATIONS have been completed without a failure on Bristol's continuing life tests—aimed at improving the Syncroverter's already superlative characteristics. Just one sample: A group of five choppers, with 400 cps drive and 12v, 1 ma resistive contact load have been going for more than 26,000 hours without failure. That's more than 2.96 years continuous operation or more than 37 billion complete cycles!

No matter what your chopper requirements, we're sure you can find the model you need among the wide selection of Syncroverter choppers and high-speed relays available . . . including low-noise, external coil types. For complete data, write: The Bristol Company, Aircraft Equipment Division, 150 Bristol Road, Waterbury 20, Conn. O-15

*T.M. Reg. U.S. Pat. Off.

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER SEVENTY YEARS

other systems using fast, low-prf pulses.

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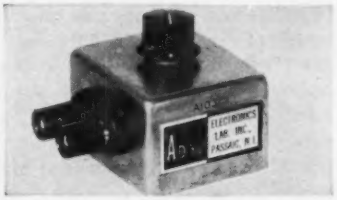
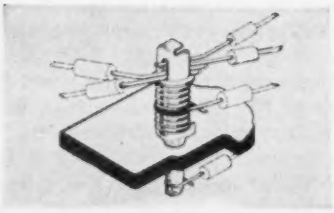


Bandpass Filters
VARIABLE UNITS

AD-YU ELECTRONICS LAB., INC., 249-259 Terhune Ave., Passaic, N. J. Type A103 is a continuously variable bandpass filter now available in audio frequency without vacuum tubes, transistors, or power supply. A matched pair of these filters, with both attenuation and phase characteristics identically equal, can be supplied on request. They are especially suitable for purifying distorted signals, for precision measurement of phase angle, or amplitude ratio, since identical phase shift and attenuation in both input channels will not contribute error in both phase and ratio measurement. Features of the unit include: The center frequency can be adjusted continuously over one decade. High input impedance presents negligible loading effect to signal source. Unit selects fundamental component from distorted signal with more than 40 db attenuation for harmonics and noise. Complete specifications are available.

CIRCLE 337 ON READER SERVICE CARD



Solderless Terminal
RELIABLE DEVICE

VECTOR ELECTRONIC CO., INC., 1100 Flower St., Glendale 1, N. Y., has released a new terminal especially for experimental circuitry. The T-30 Solderless Springclip holds up to six leads without soldering and may

WECKESSER
CABLE CLIPS

of all nylon ....

for high heat or other severe conditions

of ethyl cellulose ...

for maximum economy in average conditions

Light weight, strong, chemically resistant. No short circuits, no grounds, no corrosion, no rust. Only one fastener needed. Sizes to 1¼ inches. Write for free samples and price sheet.

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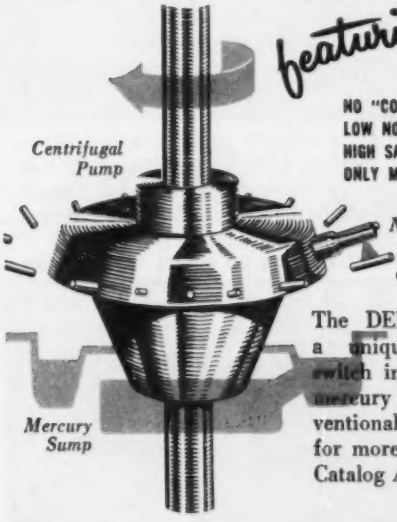
PATENTED

A HIGH SPEED MERCURY COMMUTATING SWITCH



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NO "CONTACT BOUNCE"
LOW NOISE LEVEL
HIGH SAMPLING RATE
ONLY MAINTENANCE-CLEANING

The DELTASWITCH is a unique commutating switch in which a jet of mercury replaces the conventional wiper arm. Send for more details. Ask for Catalog ATL-19.

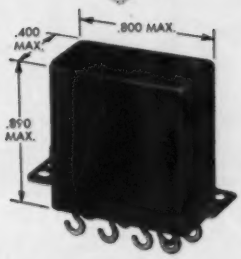
ADVANCED *Technology* LABORATORIES
A DIVISION OF AMERICAN-Standard

DEPT. AEI 369 Whisman Road, Mountain View, California

CIRCLE 212 ON READER SERVICE CARD

ALLIED CONTROL'S

NEW Polarized Magnetic LATCHING Relay



Allied Type JP Relay
Weight: 0.6 ounces
Actual Size

The inherent vibration and shock resistance and high sensitivity of Allied's Type JP ***Permanent Magnet*** Polarized Latching Relay, combined with its ability to operate from a short pulse and remain operated without holding power, make it suitable for all phases of Aerospace applications.

Because of its latching feature and availability with single or double coils, it is also suitable as a logic or memory switching element in computers and data processing applications.

OPERATING CONDITIONS:

Vibration: 5 to 55 cps at 0.195 inch double amplitude • 55 to 2000 cps at a constant 30g

Shock: 100g operational

Sensitivity: JP (single coil) 115 milliwatt maximum transfer power • JPA-JPB (double coil) 230 milliwatt maximum transfer power

Contact Rating: Non-inductive—2 amperes at 29 volts d-c or 1 ampere at 115 volts a-c
Low level contacts are available on request

ALLIED CONTROL
ALLIED CONTROL COMPANY, INC.
2 EAST END AVENUE, NEW YORK 21, N. Y.

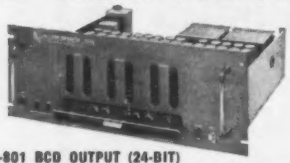
AL 309

CIRCLE 143 ON READER SERVICE CARD

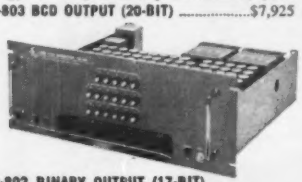
TIME TEAM

HOW EECo'S ALL-STAR LINEUP OF TIME CODE GENERATORS WINS ON EVERY POINT

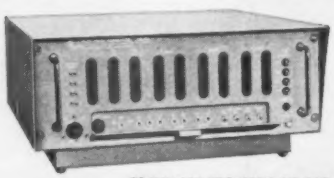
Look at these unparalleled advantages offered by EECo Time Code Generators! Frequency stability, 3 parts in 10^8, based on extremely stable crystal oscillator. 100% plug-in circuits to keep generator working for you day in and day out. Emitter-follower low-impedance outputs for long-distance transmission. Wider operating-temperature stability. Operable from aircraft power. Provision for external frequency standard. Human-engineered. Check it all out and you must choose EECo!



ZA-801 BCD OUTPUT (24-BIT)
Time-of-day code output (24-hour recycling) and any 2 of 8 pulse rates. $7,650.
ZA-803 BCD OUTPUT (20-BIT) $7,925



ZA-802 BINARY OUTPUT (17-BIT)
Time-of-day code output (24-hour recycling) and any 2 of 8 pulse rates. $7,050.



ZA-810 100 PPS CODE (36-BIT)
ZA-810-M1 IRIG TYPE C (23-BIT 2-PPS CODE)
Day-of-year plus time-of-day. Proposed Inter-Range Instrumentation Group formats. ZA-810 used by NBS on WWV. Either model, $11,180.

SEND FOR TIME CODE GENERATOR FILE 301

Electronic Engineering Company *of California*
1601 East Chestnut Avenue • Santa Ana, California • Kimberly 7-5501 • TWX: S ANA 5263

EE 0-14

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PRECISION
in a small package!

Where accurate angle measurement is vital, the job calls for Colorado Research Corporation's High Precision Angle Encoding System, now available in a 150-pound system designed for aircraft use. Precision measurement to within 3.6 seconds of arc is provided by the standard BRL system Model SE-11A; other encoders, including pure binary to 2^{19}, may be tailored to your specifications.

Applications:

Missile launching	Radar antennas
Tracking telescopes	Mechanical positioning
Stable platforms	Gyro test stands

Produced in co-operation with Norden Division, United Aircraft Corporation.

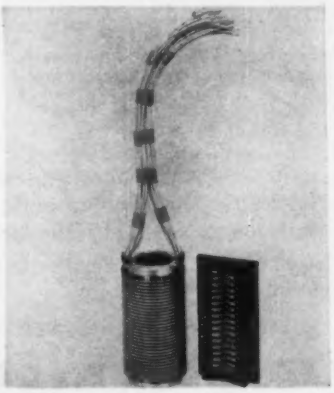
For the answer to your angle measuring problems, write Department A of:

COLORADO RESEARCH Corporation
BROOMFIELD, COLORADO • • • • • *Telephone:* DENVER—HArrison 9-3501

144 CIRCLE 144 ON READER SERVICE CARD

be used over and over. No staking is required, and Springclips fit any round 0.093 in. hole. Contact resistance between leads and the terminal is less than 0.003 ohm due to silver plating on the terminal and the unusual spring-clip holding action. Solderless Springclips are sold in sacks of 10 and 100 or in bulk. Available immediately from stock.

CIRCLE 338 ON READER SERVICE CARD



Slip Ring Assembly
1 TO 32 RINGS

FABRICAST, INC., 9835 E. Alpaca St., South El Monte, Calif. The standard slip ring assembly shown can be furnished with any number of rings from 1 to 32. Existing modular tooling permits rapid delivery without tool charges. Unit shown has an i-d of 2¼ in. and an o-d of 3½ in. and features double silver graphite brushes, hard coin silver rings and shielded leads internally grounded. It is engineered to handle instrumentation circuits at extremely low noise levels and is one of a line of standard slip ring assemblies manufactured by the company.

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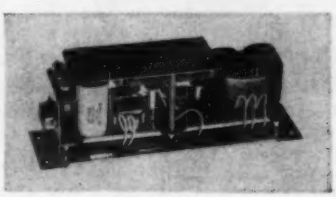


Servo Amplifier
SMALL SIZE

WESTAMP INC., 11277 Massachusetts Ave., Los Angeles 25, Calif. Model

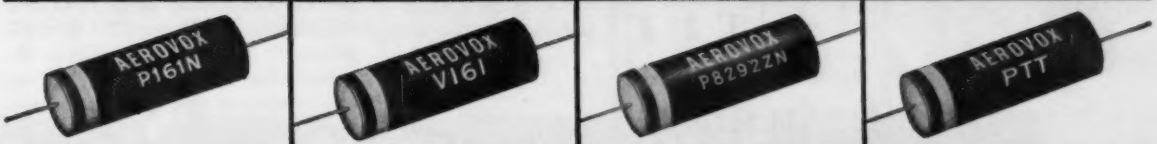
AEROVOX "POLYCAP" CAPACITORS

Now get all the advantages of metal-case construction in a lightweight, attractive plastic "Polycap" case that offers exceptional humidity resistant characteristics and prolonged capacitor life.

Exclusive "Polycap" cases provide capacitors completely free of overall wax coatings and consequently no annoying and unsightly lumps, bumps and humps. Uniform in size and appearance means faster and more efficient handling in automatic insertion equipment.

Most important "Polycap" case construction is available to you on many Aerovox capacitor types at prices no higher than inferior conventional type units. "Polycap" capacitors have established new standards of reliability, performance and appearance throughout the industry. Why not investigate these advantages today. Write for complete technical details.

AVAILABLE IN THE FOLLOWING TYPES



PAPER TUBULARS . . . P161N units with electrical and performance characteristics superior to conventional molded tubulars. Available in a complete range of voltage and capacitance ratings and in radial lead construction by specifying P159N.

"MYLAR"* TUBULARS . . . V161 units for wide application in premium priced commercial and military equipments. Operating temperature range from −30°C to +100°C. Complete range of values.

* DuPont Trademark

METALLIZED-PAPER TUBULARS . . . P8292ZN units in miniature sizes capable of operating over a temperature range of −30°C to +100°C. Available in voltages of 200, 400 and 600 VDCW in capacitances from .01 to 2.0 mfd.

ELECTROLYTIC TUBULARS . . . PTT miniature 'lytics capable of handling full size loads in industrial equipment. Ideal for all transistorized circuits. Temperature range −30°C to +65°C. Voltage ratings of 3, 6, 10, 12, 15, 25 and 50 VDCW. For both leads out one end specify PTTD.

AEROVOX CORPORATION

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WOULD 30 DAY DELIVERY HELP? Then call Helipot. We'll deliver BECKMAN® Panel Meters... in a variety of styles, shapes and models... within 30 days after receipt of your order. Specials may take 45 days.

Fact is, quick delivery and customer service go along with every BECKMAN meter... voltmeters, ammeters, milliammeters, and microammeters... in sizes ranging from 2½" to 4½".

Best of all, they are excellent meters ...and we can prove it! A Certified Test Report (which you may have for the asking) gives details of rigidly controlled tests conducted to find out just how good our meters are. In all cases, units tested met or exceeded MIL-M-10304A. Like we said: they are *excellent* meters.

Clearly, if you need panel meters, call Helipot. Delivery is dependable, quality is excellent, and the price is right. The other things we could say in favor of these meters are contained in the latest meter Data File. Send for it: your meter problems will be solved.

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POTS : MOTORS : METERS

Helipot Division of
Beckman Instruments, Inc.
Fullerton, California

INSTRUMENTAL IN YOUR FUTURE 25 YEARS 1935-1960

A425 servo amplifier is designed to provide full power to servo motors up to size 18 over the temperature range of − 55 C to + 71 C or 0 F to + 150 F at reduced cost. Gain variation under these conditions is exceptionally small due to the unique circuitry employed in addition to overall negative feedback. Unit can be provided with a synchro switch for two speed synchro systems and a twin T stabilization network. The A425 also contains its own power supply and is ready to connect to the commercial 115 v 60 cps power source. Adjustments are provided under the cover for amplifier gain, synchro switching level and network time constant. Unit is particularly suitable for use with 18 CT6b control transformers and R160 motors.

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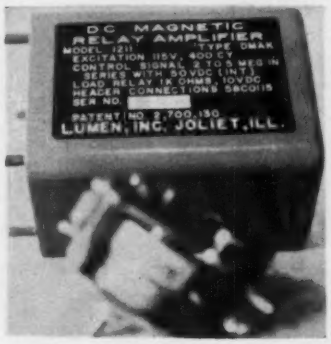

Magnetic Amplifier
SMALL AND COMPACT

LUMEN, INC., Moen Ave., P. O. Box 905, Joliet, Ill. Model 1211 bistable magnetic relay amplifier was designed and developed to meet the most stringent requirements of producers of missiles. It has as its input a photoresistor with a varying resistance of 2 to 5 megohms. It functions at extremely low levels of current in that it is capable of reacting to signals of a nature of 10 to 25 μa. Its output is in the nature of 10 v at 10 ma and, therefore, can drive a heavy duty relay coil with far greater sensitivity than previously feasible. Unit is small and compact, weighing less than 1 lb. It functions over a temperature range of + 32 F to + 125 F with extreme reliability. Small quantities of the model 1211 (1 to 5) are

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19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339			
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340			

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377	380	383	386	389	392	395	398
378	381	384	387	390	393	396	399
379	382	385	388	391	394	397	400

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3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	323	343	355	367
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	324	344	356	368
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	325	345	357	369
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	326	346	358	370
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18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338			
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339			
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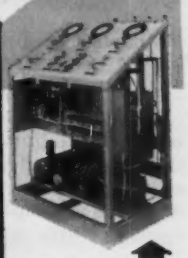

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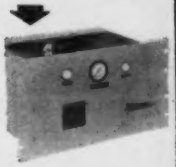

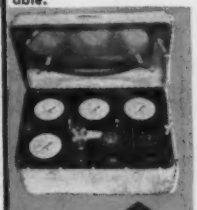

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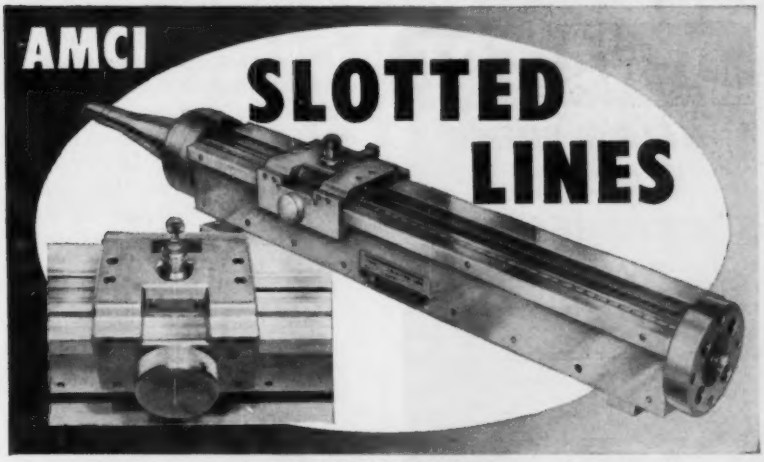

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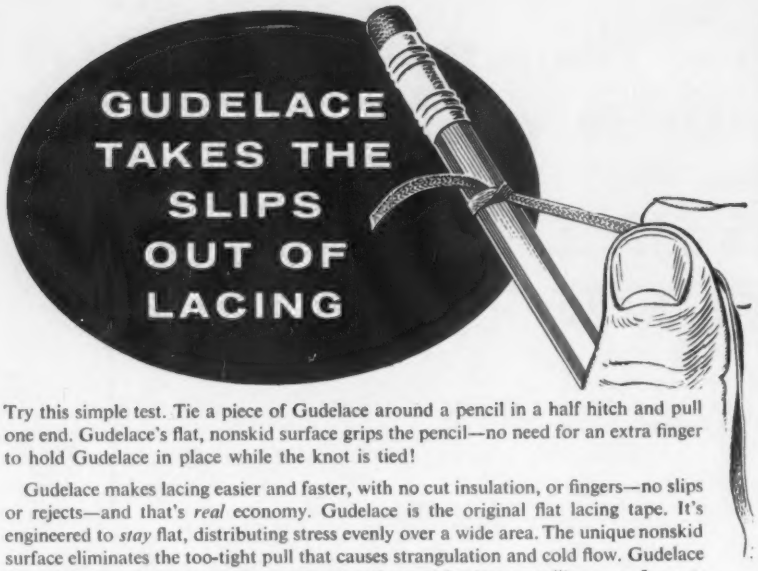

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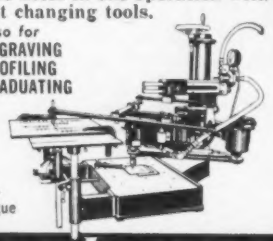

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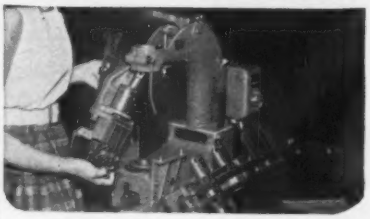

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Tone Generator
SUBMINIATURE DEVICE

ALTO SCIENTIFIC CO., INC., 855 Commercial St., Palo Alto, Calif. Model G-137 tone generator is specifically designed for missile environment. It includes ten high stability tone

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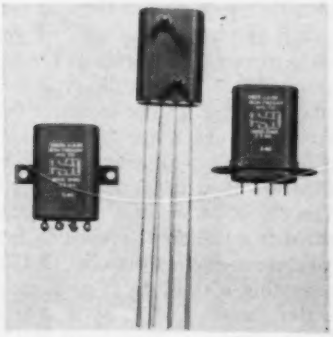

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IRON FIREMAN MFG. CO., 2838 S. E. Ninth Ave., Portland 2, Ore., has developed a new series of sensitive, microminiature relays for dry circuit and high level switching in circuits where only minute amounts of nonpolarized driving power are available. The 800N series crystal can relays, which feature 25 mw sensitivity and resilient bifurcated contact construction, conform to and exceed the test specifications of MIL-R-5757C and are available in a variety of header configurations and mounting styles. Contact life for high level switching is rated at 100,000 operations minimum, 125 C

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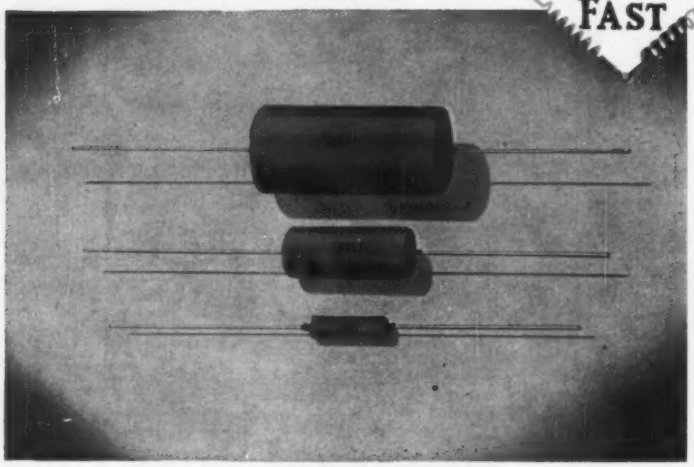

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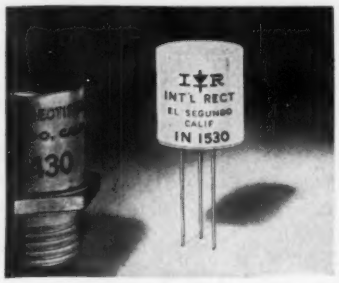

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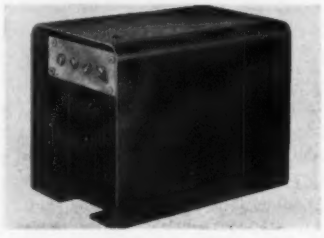

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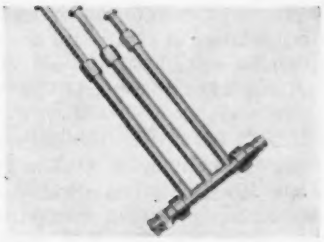

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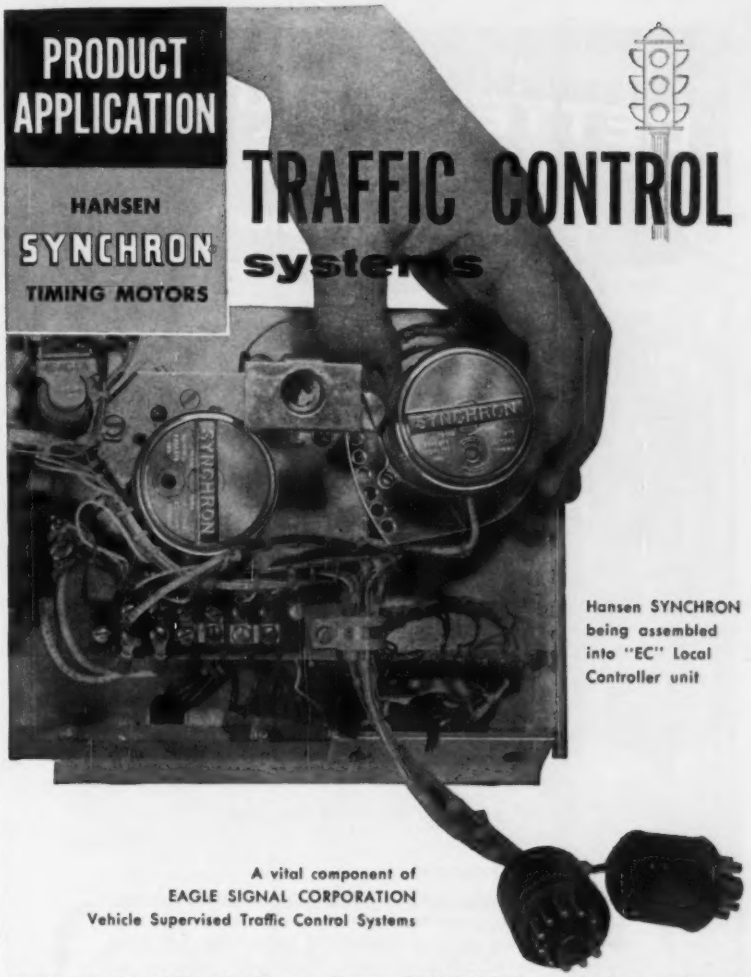
TIMING MOTORS

TRAFFIC CONTROL systems



Hansen SYNCHRON being assembled into "EC" Local Controller unit

A vital component of
EAGLE SIGNAL CORPORATION
Vehicle Supervised Traffic Control Systems

EAGLE SIGNAL CORPORATION uses Hansen SYNCHRON motors for synchronous power to govern signal timing operations in "EC" Traffic Control Systems. Hansen SYNCHRON motors regulate amber and pedestrian clearing intervals — and all other intervals which remain *constant* regardless of cycle length . . . and also govern the 4 independent traffic splits (time division for vehicular traffic) — as well as any interval which is *variable* according to cycle length. The Hansen SYNCHRON, regulating constant intervals, operates on 60-cycle power supply . . . the one governing variable intervals responds to variable frequency from the master control unit.

HANSEN SYNCHRON TIMING MOTORS were chosen by Eagle Signal after careful testing of several makes of synchronous motors. Due to the size of some timing devices and control units, a small motor with good performance characteristics was needed to fit the space limitations. After extensive tests, Hansen SYNCHRON motors were specified for: (1) high-quality performance under test; (2) lower cost; (3) long-life operation as an integral part of traffic control units. Since adoption, Eagle Signal has never experienced an assembly slowdown or stoppage due to failure on service or delivery of Hansen SYNCHRON Timing Motors.

SEND TODAY for informative folder containing specifications and technical data on all Hansen SYNCHRON motors and clock movements.

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PRINCETON, INDIANA

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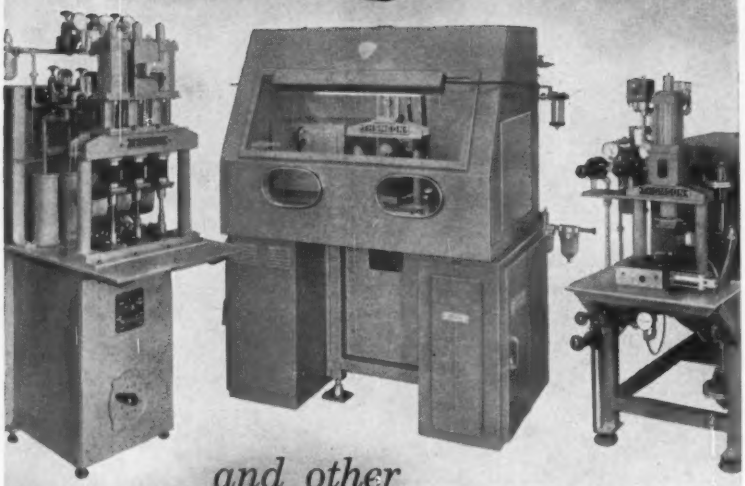
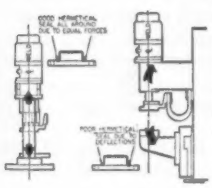


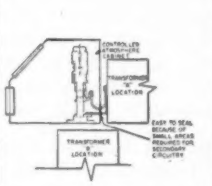
and other JEDEC devices

An exclusive **THOMSON** design has greatly improved performance and reliability in welding caps on transistors and other electronic devices which require hermetic sealing. Several models of this **THOMSON TWO-POST WELDER** have been developed to meet various product requirements.

how it works —



THOMSON'S TWO-POST Direct Tension design eliminates the inherent deflection typical of conventional "C" frame welders.

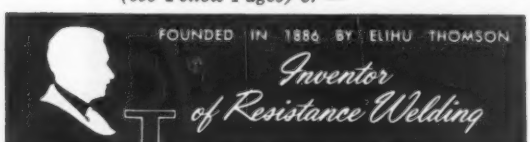


THOMSON has specifically designed this compact welding head for easy installation in a DRY BOX.

For fast follow-up and precise pressure control, **THOMSON'S** anti-friction head design incorporates a ball-bearing-guided ram and diaphragm-type air cylinder.

Larger models are provided with two transformers to obtain a concentric secondary circuit for perfect distribution of weld current in large diameter devices.

For complete details contact your nearest representative (see Yellow Pages) or —



THOMSON ELECTRIC WELDER COMPANY

161 PLEASANT STREET, LYNN, MASSACHUSETTS

LYnn 2-7710

Literature of

SILICON RECTIFIERS Tung-Sol Electric Inc., Newark 4, N. J., has available a folder of data sheets containing illustrated descriptions and mechanical and electrical data for a line of silicon rectifiers. A silicon rectifier design questionnaire is included.

CIRCLE 348 ON READER SERVICE CARD

PUNCHED TAPE PROGRAMMER Electronic Engineering Co. of California, 1601 East Chestnut Ave., Santa Ana, Calif. A two-page bulletin illustrates and describes model TP-813, a 13-channel punched tape programmer for airborne applications.

CIRCLE 349 ON READER SERVICE CARD

TACHOMETRY APPLICATIONS Waugh Engineering Co., 7842 Burnet Ave., Van Nuys, Calif., has prepared a 4-page tachometry applications bulletin, describing various methods of monitoring or controlling rotating shafts, gears or other rotating units.

CIRCLE 350 ON READER SERVICE CARD

MOISTURE GAGE Henry Francis Parks Laboratory, P. O. Box 1665, Lake City Station, Seattle 55, Wash., has published a bulletin on the model 102 moisture gage, a sensitive and accurate direct-reading relative-percentage-of-moisture meter for soils and granular materials.

CIRCLE 351 ON READER SERVICE CARD

ULTRA-PURE GOLD High Purity Metals, Inc., 340 Hudson St., Hackensack, N. J. Technical bulletin HP-101 describing 99.999 percent pure gold for semiconductor and other applications is now available.

CIRCLE 352 ON READER SERVICE CARD

MICROWAVE PRODUCTS Bomac Laboratories, Inc., Salem Road, Beverly, Mass. Specifications and illustrations for a wide line of microwave tubes and components are contained in a 24-page catalog recently issued.

CIRCLE 353 ON READER SERVICE CARD

GRAPHIC RECORDER Nesco Instruments, Inc., 638 W. 17th St.,

the Week

Costa Mesa, Calif. Two-color data sheet gives features and specifications of 10 mv fixed span graphic recorder designed expressly for laboratory use, and priced at $320.
CIRCLE 354 ON READER SERVICE CARD

PLUG-IN CHOPPER Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif., has available literature describing its model 65 transistorized plug-in chopper with transformer coupled isolating drive capable of being driven from 400 cycle line.
CIRCLE 355 ON READER SERVICE CARD

INDUCTOR WALL CHART Burnell & Co., Inc., 10 Pelham Parkway, Pelham Manor, N. Y. A comprehensive ready-reference wall chart on toroidal and variable inductors has been published for design engineers. A copy may be obtained by writing on company letterhead.

FREE SPACE ROOM McMillan Industrial Corp., Brownville Ave., Ipswich, Mass. "Your Handbook of Free Space Room Design" is a 12-page report on the many elements of FSR design, including charts for estimating needs, problems and solutions, discussion of specification pitfalls, and tear-out FSR questionnaire.
CIRCLE 356 ON READER SERVICE CARD

GENERAL CATALOG Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif., has published a new 32-page general catalog with concise descriptions of the company's pressure transducers, linear and angular accelerometers, load cells, amplifiers, power supplies, bridge balances, strain gages and force/displacement transducers.
CIRCLE 357 ON READER SERVICE CARD

THERMOCOUPLE COMPONENTS Minneapolis-Honeywell Regulator Co., Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa. New 28-page catalog G100-3 contains specifications and ordering information on replaceable components for Honeywell thermocouple assemblies.

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RESONANT REED RELAYS AND OSCILLATOR CONTROLS

Reson-ator Resonant Reed Relays and Oscillator Controls are precision electro-mechanical devices engineered to provide the finest, most economical method of detection and generation of frequencies in the audio range. Ideal for any application requiring the stability and long life characteristic of this tuning fork type device.

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Frequencies: 20 cps to 1600 cps
Coil Resistances: 1 to 1500 ohms DC
Temperature stability: ±.0025%/C° from −40°C to +100°C.
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CIRCLE 155 ON READER SERVICE CARD

North Atlantic Inc., In New Plant

NORTH ATLANTIC INDUSTRIES, INC., which started operations less than five years ago in 4,000 sq ft of plant space, has taken occupancy of a new 21,500 sq ft building in the Expressway Industrial Park at Plainview, Long Island.

The new one-story air conditioned plant will house management, marketing, engineering and test laboratories in addition to production facilities and support groups. Operations in the quarters are being conducted initially by a force of some 80 men and women; however, physical facilities have been set up to accommodate ultimately a staff of 200, which the company foresees will be required within the next year to meet anticipated levels of engineering and production.

Formed in 1954, North Atlantic started active operations in December of the following year. At that time its major activity was subcontract manufacture for various prime producers of military electronic equipment. A program of company-funded research and development soon led to the production of the company's phase angle voltmeters and self-balancing servo indicators. These, together with a group of a-c ratio boxes and other ratio measuring devices, introduced during the last year, have become the basis of North Atlantic's major product lines in the field of laboratory and ground support instrumentation.

North Atlantic currently produces its proprietary line of phase angle voltmeters, ratio boxes, Lissajous oscilloscopes, phase sensitive converters, and servo data converter/indicators in a variety of standard and custom configurations for both laboratory-production test and military ground support applications. According to Malcolm D. Widenor, North Atlantic's president, one of the principal company programs scheduled in the new facility is the expansion of its line of a-c ratio measuring instruments to provide one-source integrated test and measurement systems built about its proprietary products.

Previously located in Westbury, L. I., North Atlantic carried out three successive plant expansions during 1959 to meet a three-fold increase in sales during that period. Present Plainview facilities are geared to a three-fold increase in 1960 with ultimate expansion to 40,000 square feet to provide future manufacturing facilities capable of a much increased rate, by taking advantage of the advanced production line techniques.

Semicon Appoints Works Manager

THE APPOINTMENT of Edward E. Fellman as works manager of Semicon, Inc., Bedford, Mass., has been announced. He will handle all production and production related activities for the company's expanding line of top-hat, stud, miniature and epoxy silicon rectifiers.

Fellman was formerly senior industrial engineer for the Semiconductor Division of Sylvania Electric Products, Inc., in Woburn, Mass. He had been associated with Sylvania for the past four years before taking his new post.

Hammarlund Expands Manufacturing Plant

GROUND has been broken in Mars Hill, N. C., for a $350,000 addition to the plant of Hammarlund Mfg. Co., a subsidiary of Telechrome Mfg. Corp.

The expansion is scheduled for completion in December. The plant area will be tripled to 80,000 sq ft and employment will eventually be more than doubled according to president Joseph R. McPhee.

Hammarlund, which is celebrating its fiftieth anniversary this year, manufactures radio receivers and transmitters, electronic components, and automatic control systems for industry. The company is in the process of expanding its product line and within the next six months is planning to market a new line of radio marine equipment and mobile industrial transmitter-receiver equipment which will be manufactured in Mars Hill.

U. S. Testing Names R. L. Hopkins

APPOINTMENT of Richard L. Hopkins as manager of the development engineering department of U. S. Testing Co., Inc., Hoboken, N. J., is announced.

Hopkins has had extensive experience in the metallurgy of rare metals and their application in the electronic, chemical, and nuclear industries. Prior to joining U. S. Testing, he headed his own consulting engineering firm specializing in engineering management, product development, and technical marketing.

As manager of development engi-

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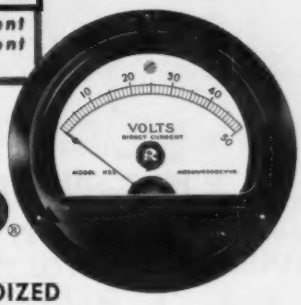

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England's Finest Components.

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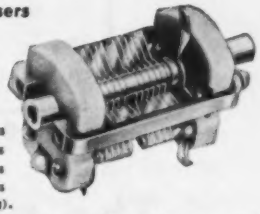

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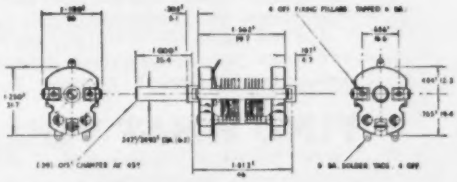
4—63 uuF .015" Air Gap 7.F.8.M. Vanes
(The last line is .36" longer than the drawing).

SPECIFICATION—S.L.C. Law. Siliconed low loss ceramic insulation. Brass Rotor and Stators, soldered and silver plated.

Delivery six weeks after order received. Retail price $3.95.
(*prototype quantities usually in New York stock*).

AIR SPACED TRIMMER C.808 "SPLIT STATOR."



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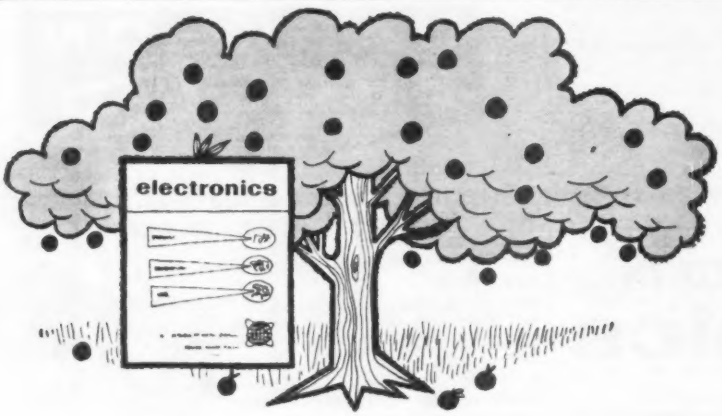

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neering, Hopkins will direct U. S. Testing's activities in the design and manufacture of scientific instruments, testing apparatus, and measurement systems, to meet the expanding industrial requirements for technical quality assurance. His department is staffed by research and development engineers embracing the full range of major scientific disciplines.

Mandrel Industries Promotes Sundt

PETER C. SUNDT was recently named administrative assistant to the executive vice president of Mandrel Industries in Houston, Texas. He will be chief administrator and technical director of Mandrel's two Houston divisions, Electro-Technical Labs and Electric Sorting Machine Co.

Sundt began his career as an engineer with Hughes Aircraft Co., coming to Electro-Technical Labs in 1953 as a design engineer. He has since been chief engineer and general manager of Electro-Tech France with headquarters in Paris.

J. W. Noland to Head Gonset Division

APPOINTMENT of James W. Noland to the position of general manager,

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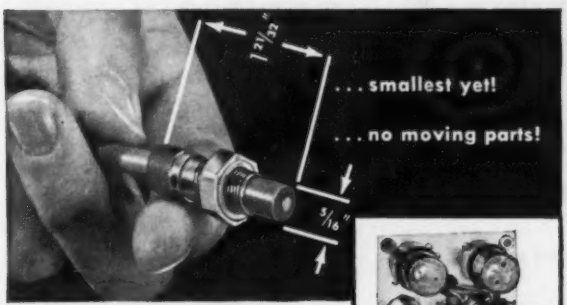

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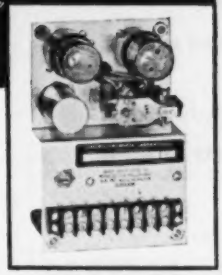

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Type C is basically a sine wave generator with provision for optional complex waveform output.

FOR INFORMATION, CONTACT Dept. 2309

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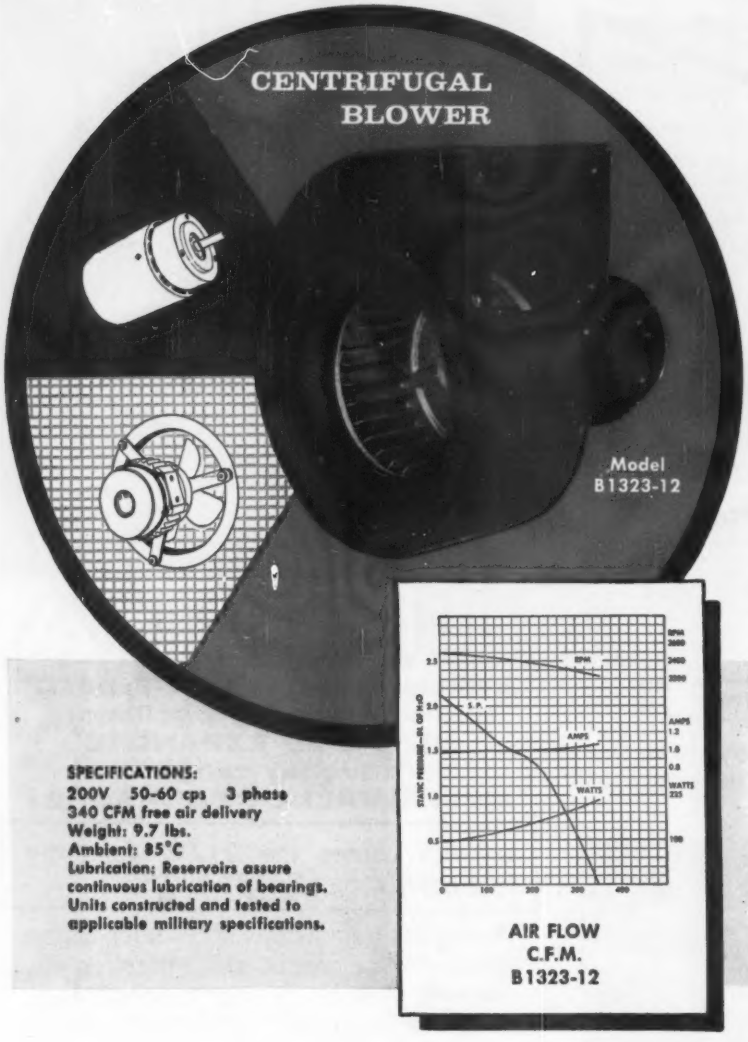

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Gonset Division, Young Spring and Wire Corp., Burbank, Calif, has been announced. He was formerly manager of manufacturing for this producer of fixed and mobile radio communication equipment.

Noland's experience encompasses a 20 year period, includes responsible positions in management, engineering and production. Prior to joining Gonset he was factory manager for Globe Electronics, division of Textron, Inc., Council Bluffs, Iowa.

Avtron Manufacturing Names Chief Engineer

JOHN R. BODKER, was recently appointed chief engineer of Avtron Manufacturing, Inc., Cleveland, O. He joined Avtron as a project manager three years ago from Jack & Heintz where he was manager of the control section in their engineering department.

Avtron, a seven-year old company, supplies test and ground support equipment to the aircraft, missile and nuclear fields. It employs over 125 skilled engineers and technicians at its main Cleveland plant.

CPPC Promotes E. J. Gately, Jr.

CLIFTON PRECISION PRODUCTS, INC., Drexel Hill, Pa., announces the appointment of Edward J. Gately, Jr. as manager, Systems division. He was midwestern sales manager of CPPC at the time of his appointment.

Previously he was a project engineer, Armament division, White-Rodgers, St. Louis, Mo., and before that a project engineer at Clifton Precision for five years.

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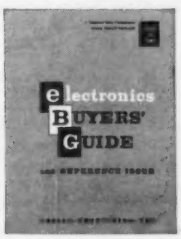

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RECEPTION
The 85 foot parabolic antenna at Goldstone, California built in 1958 and used in tracking and recording telemetry from U.S. spacecraft.

TRANSMISSION
This 85 foot antenna, seven miles from the reception facility, has recently been put in operation to transmit signals to U.S. spacecraft.

SENIOR RESEARCH SPECIALISTS

New opportunities involving advanced research and development projects are now open at JPL in the Laboratory's Telecommunications Division for engineers and scientists capable of assuming a high level of technical responsibility.

SOME SPECIFIC OPENINGS IMMEDIATELY AVAILABLE

Communication Specialists
Execution of RF tracking and communication system projects.

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Research Scientists
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Electrical engineering degree plus experience in miniaturized semiconductor electronics development. To design servo, pickoff, and other electronics for use with gyros and accelerometers.

ENGINEERING PHYSICIST

Physicist with practical and theoretical understanding of mechanics, magnetism and electricity to analyze and develop inertial sensors of novel and original design.

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(Classified Advertising)

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Cables: TELSERSUP

See pages 594, 595 of 1960 Electronics Buyers' Guide for a more complete listing

LIBERTY ELECTRONICS INC.
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New York 12, N. Y.

CIRCLE 460 ON READER SERVICE CARD

LOOKING FOR USED/SURPLUS ELECTRONIC EQUIPMENT/COMPONENTS?

For an up-to-date listing of such equipment see Searchlight Section of Sept 9th.

SEARCHLIGHT Equipment Locating Service

NO CHARGE OR OBLIGATION

This service is aimed at helping you, the reader of "SEARCHLIGHT", to locate Surplus new and used Electronic equipment and components not *currently* advertised. (This servce is for USER-BUYERS only).

How to use: Check the dealer ads to see if what you want is not *currently* advertised. If not, send us the specifications of the equipment wanted on the coupon below or on your own company letterhead to:

Searchlight Section Locating Service
c/o ELECTRONICS,
P.O. Box 12, N. Y. 36, N. Y.

Your requirements will be brought promptly to the attention of the equipment dealers advertising in this section. You will receive replies directly from them.

Searchlight Equipment Locating Service
c/o ELECTRONICS, P. O. Box 12, N. Y. 36, N. Y.

Please help us locate the following equipment components.

.....
.....
.....

NAME .....
TITLE .....
COMPANY .....
STREET .....
CITY 9/30/60

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Instant Covering for All Applications!

Zippertubing, an economical on-the-job method of jacketing, is a flat tape, available in a wide range of materials, that has a patented extruded plastic track electronically welded to both edges. The tape or jacket is wrapped around the object to be covered so that the tracks engage, then "zip" shut. If permanent closure is required, a special sealant is provided that fuses the tracks together.

GENERAL PURPOSE
Standard without overlap. Generally conforms to MIL-I-631C.

MILITARY TYPE
with overlap Type 74 meets requirements of MIL-I-7444B. Type 63 meets MIL-I-631-C. QPL certificates of conformance or test reports furnished on request.

SHIELDED ZIPPERTUBING®
copper. These conductive metals are laminated to vinyl-impregnated Nylon or glass cloth. When zipped around wires, it provides immediate 100% coverage for grounding RF and UHF interference.

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and precision

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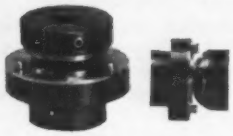

TYPE ASC-1, 2 FEATURES:

- **Compact • Lightweight**
- **Wide Torque Range**
- **Adjustable**

ALI Adjustable Slip Clutches are instrument type clutches used to protect components against excessive or inertia shock loads. These units are adjustable over a wide torque range without being removed from the system. Range of sizes: Type ASC-1 with bores from .120" to .250", Torque Range 2-20 oz. inches, other on special order; Type ASC-2 bores from .120" to .125", Torque Range 2-8 oz. inches.

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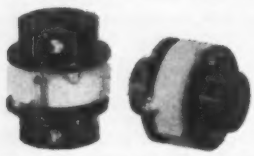

TYPE MPC-1, 2, 1C, 2C FEATURES:

- **No backlash**
- **Accommodates Lateral and Angular Misalignment**
- **Compactness and Lightweight**

Choice of types offer clamping or set-screw hubs, nylon or stainless steel inserts. Range of bores accepts shafts from .120" to .250". Backlash-free torque capacity of type MPC-1 16 oz. inches; Type MPC-2 8 oz. inches.

For details request data sheet.

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subsidiary of

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Life — over 700 hours reported
Peak power available — more than 10 kw. (More power than you can get from any other device at this frequency)
Duty cycle — up to 0.001. (For the BL-221, it is 0.00055)
Vibration — will survive 10 g's
Shock — 50 g's at 4 millisec
Lightweight — 7.25 lbs
Mounting — mates to modified standard flange
Ruggedized — Ceramic and metal construction
Fixed tuned

Band	Tube Type	Frequency Range (MC)	Minimum Peak Power (KW)	Output Mates with
V	BL-235	51,000–54,000	10	UG385/U
V	BL-236	54,000–57,000	10	UG385/U
V	BL-237	57,000–60,000	10	UG385/U
V	BL-221	60,000–70,500	10	UG385/U

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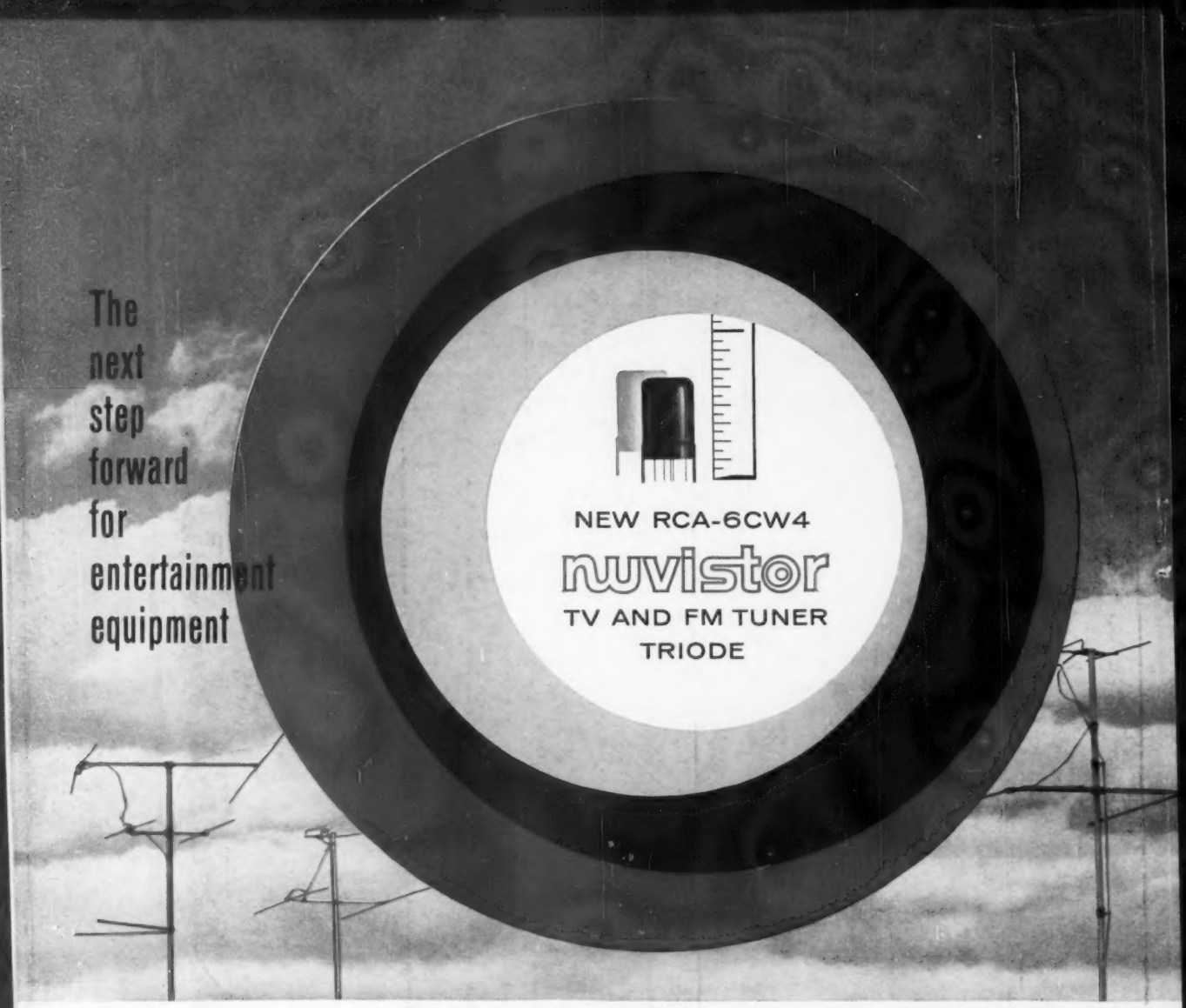

Now commercially available for TV and FM tuner designs

2 to 4 db better NOISE FACTOR than tubes currently in use in TV receivers.

Superlative Performance—and not just tiny size—is the reason this latest RCA nuvistor triode should soon be the preferred rf-amplifier tube in entertainment equipment. Nuvistorized TV tuner circuits can make possible excellent reception in fringe areas where reception is now unsatisfactory.

Noise Factor is 2 to 4 db better than that of other tuner tubes in commercial use. In addition, this mighty midget provides this unmatched combination of advantages:

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High Transconductance PLUS high gm to I_b ratio (12500 μmhos at 8 milliamperes and 70 volts)

Very Small Power Requirements: Plate and heater input—each less than 1 watt. PLUS ALL THE INHERENT ADVANTAGES OF NUVISTOR DESIGN: exceptional reliability, excellent stability, extreme ruggedness, small size, light weight, high unit-to-unit uniformity, extreme sensitivity, very high input impedance, and high perveance. The last word in entertainment rf-amplifier triodes is nuvistor 6CW4!

For further information, see your RCA Field Representative—or write to RCA Electron Tube Division, Commercial Engineering, Section I-19-DE-5, Harrison, N. J.

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 ± 10% volts
Current at 6.3 volts	0.13 amp.

TYPICAL OPERATION	
Plate Voltage	70 volts
Grid Supply Voltage	0 volts
Grid Resistor	47000 ohms
Amplification Factor	68
Plate Resistance (Approx.)	5440 ohms
Transconductance	12500 μmhos
Plate Current	8 ma

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